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Heightening the Assuan Dam Across the Nile.

By FREDERICK HALL FOWLER.*

When the new Assuan Dam is complete it will form the key of the Egyptian irrigation system. It is probable that nowhere else in the world can be found an instance where the welfare of a people is so intimately connected with the success of a single engineering structure. On the Assuan Dam the nation and the government will depend. Egypt has existed for countless centuries without such a structure, but the results of the "basin" system of these centuries, when compared with the wonderful yield from the newer perennial system, leaves no doubt as to which will win in the struggle that has been going on since the days of Mehemet Ali.

The original dam† was begun in 1898 and completed in 1902, and provided the first storage reservoir in modern Egypt. The excavation was estimated at 408,000 and the masonry at 484,000 cu. yds., but owing to cemented streaks in the granite bed rock, the total excavation rose to 824,000 cu. yds. (202% of the estimate) and the masonry to 704,000 cu. yds. (145% of the estimate). In consequence, the cost of the structure reached a final total of $11,900,000, making the cost $14.95 per acre-ft. for the 795,000 acre-ft. impounded.

From the first two years' working of the system it became evident that the dam, then proved a success both structurally and financially, despite its excessive cost over the original estimates, must soon be heightened to obtain additional storage. The official statement of the government's intention to heighten the dam is set forth in the "Dispatch from the Earl of Cromer Respecting the Water Supply of Egypt, March 15, 1907." From this dispatch the following extract is taken, the bracketed portions having been interpolated by the writer:

> . . . In the first place, I would observe that there can be no doubt of the enormous benefit which the Assuan reservoir has conferred on Egypt. The actual direct gain to the Egyptian Treasury has, indeed, been insignificant. The indirect gain has been considerable, but it is difficult to state precisely to what it amounts. The reason why the actual return to the Treasury has been small is that it was thought best to impose a very light land tax on the lands affected, and thus leave the benefits to be derived from the reservoir to fructify in the pockets of the population. On the other hand, the benefit to the country has been enormous. Sir William Garstin estimates that the sale value of the lands already provided with perennial irrigation [about 73% of the total area falling under the original dam] has been increased by no less than £E24,510,000* [$1,215,000,000], and that, when the canals now in course of construction are completed, this figure will rise to no less than £E28,312,900 [$1,405,000,000] The increased rental value is already £E1,465,000 [$7,260,000], and will eventually rise to £E2,022,350 [$10,000,000]. The whole of this rise in value is directly attributable to the construction of the dam; in addition to this the cotton crop, the value of which was estimated last year at £E28,000,000 [$1,388,000,000], has been secured.
>
> . . . The value of the cotton crop in the area reclaimed will alone amount to from £E3,500,000 to £E4,000,000 [$17,350,000 to $19,850,000] a year. [This last sentence refers to the area of 950,000 acres to be brought under cultivation by raising the dam.]

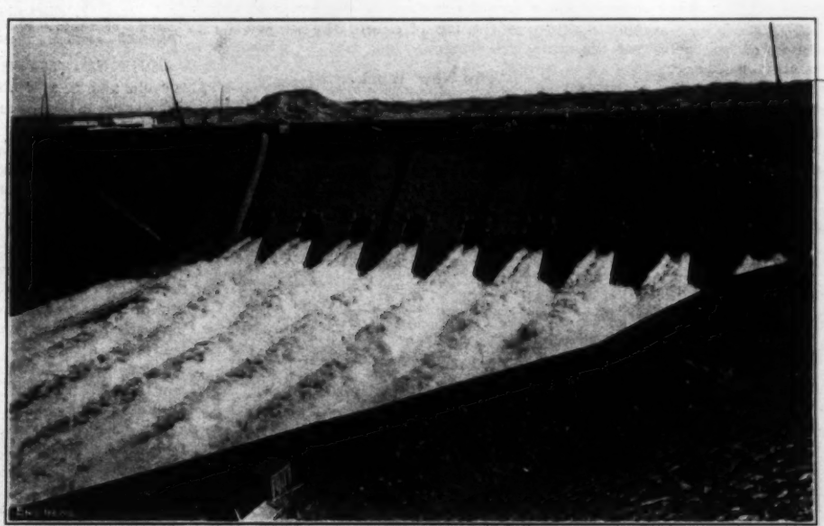
In English acres, the Egyptian acre or feddan equals 1.03808 acres, the area brought under perennial cultivation by the original dam was approximately 420,000 acres, and the increase by heightening the dam will be 988,000 acres. The acreage brought under the original was converted basin land in middle Egypt, while the addition will be waste land reclaimed from the northern tracts of the Delta.

In pursuance of the determination to undertake the new work, negotiations were begun with Messrs. John Aird & Co. (constructors of the original dam, and of the weir at Assiut), and in April, 1907, a contract was signed, in which the firm agreed to heighten the dam, according to the plans and specifications, for the sum of £E1,036,788, or $5,110,000. In addition to this a contract was made with Messrs. Ransomes & Rapier for alterations in iron and steel work, and for additional material. Grants to archaeological societies, compensation for land and for riverside villages flooded in Nubia, will, it is estimated, bring the total cost of the increase in storage of 1,070,000 acre-ft. up to £E1,500,000 ($7,410,000). This will mean an expenditure of $6.90 per acre-ft.

According to these plans, shown in Figs. 2 and 4, the dam is not to be lengthened, but its height is to be increased about 16 ft. and its section enlarged proportionately by adding new masonry to the down-stream face. This will require some changes in the navigation canal and the controlling works. The writer visited the dam last winter and the following account of the new construction is drawn largely from that visit:

The Old Dam.

At first sight of the Assuan Dam one is astounded at its stupendous length. It is this extreme length (over 6,260 ft.), however, that made the dam a success, for it must be remembered that a two-fold problem had to be solved by its designer. First, the dam had to pass without check the heavily silt-laden flood of the Blue Nile, with its possible maximum of 475,000 sec.-ft., and second, it had to perform the usual function of impounding the clearer waters following, from the Sobat and from the White Nile. The numerous sluices necessary to pass the flood at an allowable velocity, without checking it enough to throw down sufficient silt to impair the reservoir, rendered a great length of dam not only desirable but absolutely imperative. The Straits of Kalabsha site, above Assuan, while far preferable for an ordinary storage dam, had to be discarded on account of being too short. The Assuan site was the only choice that provided secure foundations together with sufficient length to accommodate the necessary number of sluices.



DISCHARGE FROM SLUICE SET NO. 1 AS SEEN FROM NAVIGATION CHANNEL.

"SOLID" AND "PIERCED" DAM SECTIONS.—It must be borne in mind that the Assuan Dam has two distinct gravity sections, the "solid" and the "pierced." This arises from the fact that the site, while the very best obtainable, was more than long enough to accommodate the sluices and their intervening piers, and the sluices were, therefore, concentrated as far towards the west end of the dam as the specifications allowed, and the east end was constructed "solid," in the ordinary manner. The "solid" section presents no novelty; it is, as the name implies, a solid gravity section, proportioned to comply with the conservative conditions laid down by the commission of consulting engineers that passed on Mr. Willcock's plans. Since the piers of the "pierced" dam have to sus-

*Hydraulic Engineer, Palo Alto, Cal.

†Eng. News, Dec. 28, 1899, p. 418; Sept. 26, 1901, p. 221; Aug. 15, 1902, p. 106.

*£E is Pounds Egyptian, one of which is worth $4.94, instead of the $4.87 value of the Pound Sterling.

tain not only the water pressure on their own upper sides, but also the pressure carried by the intervening sluice-gates, their gravity section has to be much heavier than that of the "solid" dam. The maximum pressures in the masonry have been calculated as 8,950 lbs. per sq. ft. on the down-stream side with the small Set No. 1, as seen from below. The heavy retaining wall in the foreground turns the race from the Navigation Channel embankment into the river. The work at the left is up to the level of the roadway of the original dam, and the construction gangs may be seen still working at the right.

THICKENING.—In order to maintain the stability of the new dam as a gravity structure, the original dam is being thickened, in the process of heightening, by the addition of a strip of masonry 16.4 ft. in thickness (measured normal to the original surface) along its entire down-stream face (Fig. 4). When completed, this

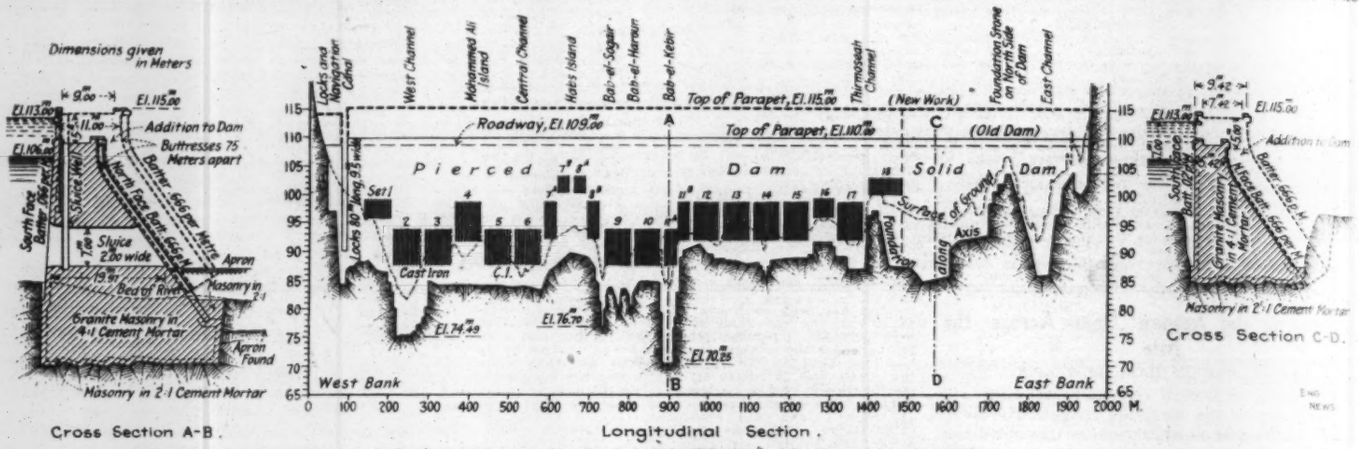


FIG. 2. DETAILS OF THE HEIGHTENING OF THE ASSUAN DAM.

reservoir full, and 13,000 lbs. per sq. ft. on the up-stream side with the reservoir empty. We have, then, the following arrangement for the whole dam: from the west end the first 4,850 ft. (approximately) is of the "pierced" section, and accommodates the navigation channel and all the 180 sluices. From the east end of the "pierced" dam to the east abutment, 1,400 ft., the "solid" section is used. The total length of the whole structure is about 6,250 ft.

Fig. 6 shows the "solid" portion of the new work, as seen from the construction bridge (in the background of Fig. 3) near the end of the "pierced" section. The parapet of the old dam shows above the new masonry. At the extreme left are the tracks which come through the gash in the hills at the back, from the railroad and quarries at Shellal. One of the administration buildings shows beyond the palms.

The change to the heavy, or "pierced," section, from the light, or "solid," section, is made at the buttress shown at the background of Fig. 3. This view is looking east, at Set No. 18 of the sluices (see Fig. 2). The end of the new masonry of the "solid" portion is just beyond the buttress, and under the crane. Along the face of the original work, at the lower edges of the sluices in the foreground, is a footway for the drillers engaged in setting the 1¼-in. tie rods that support the new masonry and bond it to the old, as described hereinafter. In the pit below, a gang is working on the foundation of the new work. The crane shown in this view is typical of those in use on the dam.

PROTECTIVE WORKS.—The original dam had been in commission but a short time, when it became apparent that the river bed, just below the sluices, was not sufficiently sound to withstand the rush of the silt-laden floods, and the terrific hammering of the discharge from the upper sets of sluices. To check this tendency to scour and undercut, extensive protective works, in the form of wing-walls, water cushions, and an apron, were constructed below the dam. At present it is possible to lay the bed of the river bare enough, at almost any stage except flood, to examine the bottom at any desired set of sluiceways. These protective works, while needing constant watching, are reported to be giving perfectly satisfactory results. The point where most constant and harmful erosion is likely to occur is at the retaining wall, where the embankment along the Navigation Channel flanks the main river. Here the rush from the first set of sluices is deflected back into the stream in a terrific swirl, and undercutting is sure to take place.

Figs. 1 and 7 give a faint idea of the discharge from the Assuan sluices. The first gives the discharge at about three-quarters capacity from the buildings showing above the dam are on Awad Island, in the reservoir. Fig. 7 was taken at the same time, and gives the rush of waters from the same set of sluices as in Fig. 1, but as seen from a point on the dam, and near its west end. The Navigation Channel passes down behind the long embankment. In the foreground is the top of the new masonry of the reinforcement, and above the surface of the water in the lower center is the top of one of the wing-walls of the protective system.

The New Work.

The work of heightening the Assuan Dam will consist of three main operations: (1) Thickening the present dam by the addition of a masonry

Fig. 3. View of Pierced Section.

reinforcement on the down-stream face; (2) bonding this new work into a homogeneous whole with the original dam; (3) building the whole structure up to the desired height, and making the necessary changes in the Navigation Channel.

face will, therefore, slope from the bottom of the reinforcement up to an elevation of 117.27 ft. above datum on a batter of 2 on 3, and then swing on a circular curve of 29.52 ft. radius to a vertical plane beginning at an elevation of 133.66 ft. and running up to the coping. This will make the thickness in feet just below the coping as follows:

	Original dam.	Heightened dam.	Change.
"Solid" section...	17.78	30.89	13.11
"Pierced" section.	22.96	36.07	13.11

BONDING.—The efficiency of the bond between the old and new work, especially considering the difference in temperature between the original dam and the newly laid masonry of the reinforcement, was judged to be of the utmost importance by the designer, the late Sir Benjamin Baker. His treatment of this problem constitutes, perhaps, the most unique point in the new work. Between the up-stream surface of the new work and the down-stream surface of the original dam, a hollow space of 0.5-ft. measured normal to the old work, will be left, from the foundation to the top of the old dam. To support the new masonry and to act as ties, 1¼-in. iron rods about 8.25 ft. long are sunk into the old masonry so that they project about half their length, and are built into the new masonry as it advances. These rods are in rows one meter apart both horizontally and vertically, and before they are covered in by the new work, stick out of the old dam much like the teeth of an old-fashioned harrow.

The cavity between the two structures is divided into comparatively small sections by vertical partition walls 6 ins. thick, spaced about 49 ft. apart, along the entire length of the dam, and running down to the foundation in each of these compartments, or "bays," are upright perforated iron pipes about 3 ins. in diameter, bent to fit along the face of the old dam. When the masonry reaches the level of the roadbed of the original dam, these pipes are plugged at the top, and the openings of the "bays" are sealed along the dam, to prevent spalls and other foreign matter from falling into the cavities, and to aid in bringing the two portions of masonry to the same temperature by keeping out the ordinary heated air.

When it is judged that both structures have reached a uniform temperature along their adjoining surfaces, the capacity of each "bay" will be measured by pumping in water in measured volumes. This gaging will form a close check on the last operation of the bonding process which will be to grout each "bay" by pouring cement grout down the perforated pipes. The grouting will thus be done from the bottom upwards, for it will not pass the perforations in the pipe until the level of the grout in the "bay"

is reached. Were this grouting to be attempted in a cavity extending the full length of the dam, it would, in all probability, result in very uneven work, but with the space divided into bays, and the capacity of each bay measured previously, any uneveness should easily be detected and remedied.

It seems that the bond thus obtained should be fully as strong as, if not stronger than, that along any other plane of like area in the dam, and should effectually counteract any tendency of the old and the new work to shear apart from unequal expansion due to differences in temperature.

Several of the grouting pipes show along the portion of the face of the old dam in Fig. 5,

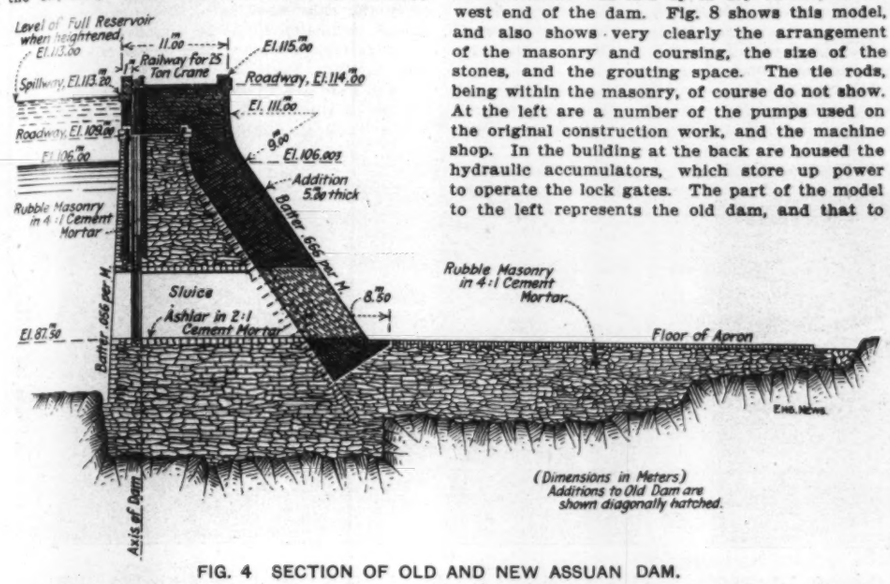


FIG. 4 SECTION OF OLD AND NEW ASSUAN DAM.

Fig. 5. Reconstruction Work Near Sluice Set No. 1.

above the new work, following the face of the masonry down into the "bays" in exactly the same way that the templates follow the face of the new work. This picture shows construction work just outside of the Navigation Channel, looking eastward. The wing wall in the lower corner is the retaining wall outside the embankment of the Navigation Channel.

In planning the work a full-sized model (in section) of a fragment of the old dam and the reinforcement was laid up in dry rubble, at the west end of the dam. Fig. 8 shows this model, and also shows very clearly the arrangement of the masonry and coursing, the size of the stones, and the grouting space. The tie rods, being within the masonry, of course do not show. At the left are a number of the pumps used on the original construction work, and the machine shop. In the building at the back are housed the hydraulic accumulators, which store up power to operate the lock gates. The part of the model to the left represents the old dam, and that to the right the reinforcement 16.4 ft. thick. Between the two parts may be seen the end of one of the grouting bays. One-man rocks are used almost exclusively in the cores of both works, and in the work it will be noted that the bedding planes of the courses are normal to the surface of the original dam, and form a sawtooth in a horizontal direction. With the large supply of cheap native labor it was deemed better to handle smaller stones by hand than to place larger ones by machinery.

HEIGHTENING.—The process of heightening the dam, when the grouting is completed, will be the same as in any masonry dam under similar conditions as to location, climate, and labor. The work will present no engineering novelty, but the conditions of the climate under which it will be executed are severe, and may best be understood by reference to Mr. Fitzmaurice's paper on the construction of the original dam (Nile Reservoir, Assuan, Minutes of Proc. Inst. C. E., Vol. 152, 1902-3; Part 2, Paper 3361). He states that for three months the mean shade temperature was 108° F., the mean night 85°, and many nights the mercury did not drop below 100°. On some days in June the thermometer registered 160°, and on no day in that month did the maximum temperature in the sun fall below 140°. In June no work was carried on from 12 to 4 p. m.

It is said in Egypt that the natives suffer nearly as frequently from heat prostrations, when working in the sun, as do the Europeans, but what the statistics in the case are the writer was unable to find out.

The comparative elevations of parapet wall, roadway, and water-surface for the old and the new structures will be as follows:

	Original dam. ft.	Heightened dam. ft.	Change. ft.
Parapet wall	130.38	146.78	+16.4
Roadway	127.10	143.50	+16.4
Water surface	117.26	140.22	+22.96

All these elevations are above the lowest point in the foundation as 0 datum, which is at an elevation of 230.42 ft. above mean sea at Alexandria.

It is interesting to note that while the top of the new parapet wall is only 16.4 ft. above that of the old, the level of the water surface with the new reservoir full will be 22.96 ft. above that in the original. From this it will be seen that the "freeboard" of the heightened dam above the water's surface will be only 6.56 ft., as against 13.12 ft. in the original. Partially compensating for this reduction in "freeboard" is the addition of an emergency spillway at an elevation of 140.88 ft., emptying down the gate wells into the sluices. In this particular the new dam will differ from the old, which had but one means to check sudden rises in the reservoir, i. e., by opening the sluice gates. The spillway in the new dam will probably come into use but infrequently, and on slight temporary rises in the reservoir water level.

The width of the roadway on the top of the new "pierced" dam will be about 29.5 ft. in the clear between the parapet walls, but above the sluices this width will be reduced to about 26.25 ft. by the hand gears which actuate the sluice gates. The roadway, as has been stated, will be at an elevation of 143.50 ft. Along it will run a track for the 25-ton crane, and two small tracks for handcars used in transporting materials and passengers.

HEAD OF RESERVOIR.—The head of the reservoir when full, which in the original is near Ibrim, 140 miles up-stream from the dam, will be changed by raising the water-level to an elevation of 140.22, to a point about 180 miles from the dam—or just up-stream from the important temple of Abu Simbel, which will not, however, be flooded.

The following temples (all belonging to the Roman period) will be more or less seriously inundated by the rise of water to 140.22 ft.:

Temple.	Elevation. ft.	Below surface. ft.
Philae	111	29
Debod	114	26
Taifa	121	19
Kalabsha	130	10
Dekka	130	10

While the flooding will necessitate the removal of a number of small Nubian villages to higher ground, the damage done will not be nearly so great as would be expected by a person used to the lower course of the Nile. After the first cataract, at Assuan, is passed, the whole nature of the valley changes, and the sandstone plateau comes nearly up to the river's edge on either side. The native villages are much smaller, and the fields fewer and poorer, than below the dam, so the flooding causes comparatively little damage. The Nubians are being recompensed for their losses at figures which are to them highly satisfactory.

Fig. 6. View of the Solid Portion of the Assuan Dam, Looking From West to East.

Changes in Navigation Channel.

At present the Navigation Channel passes the dam by means of four locks (not counting the lock near the rapids, some distance downstream), at the west end, each 262.4 ft. long by 31.16 ft. wide. The dimensions of the lock gates are:

	Height of gate, ft.	Level of sill, ft.
1	62.32	71.34
2	62.32	71.34
3	49.20	61.50 (Lock bed)
4	39.36	51.66 (Lock bed)
5	29.52	41.82 (Lock bed)

caused by its moving slowly through the water. This arrangement also does away with all ropes and chains under water.

As may be seen from the half-tones (Figs 10 and 11) the gate as a whole can be divided, for convenience in description, into its three main parts, beginning at the top: the carriage and operating mechanism; the roller bearings and bascule; and the gate proper.

The carriage consists of two longitudinal members, carrying seven transverse beams, on which is set the deck to support the operating

The gate proper, the upper end of which shows between the lower edge of the bascule girder and the water, consists of a frame of two wood-faced, vertical jambs, to which are framed 14 bowstring girders (in the largest gate) that carry the sheet-steel skin. These girders are so spaced vertically as to be equally loaded. The wood facings on the gate jambs bear against iron castings that are bolted to the masonry. In each gate are twelve sluices, arranged in four groups of three each, the three valves of each group being in line vertically, and operated as

FIG. 7. TAIL-RACE FROM SLUICE SET NO. 1 LOOKING TOWARD RETAINING WALL OUTSIDE OF NAVIGATION CHANNEL.

FIG. 8. MODEL OF ASSUAN DAM SECTION SHOWING OLD AND NEW WORK.

To obtain the added lift of 22.96 ft. needed for vessels to pass the new dam with the reservoir full, a fifth lock will be placed in the series, just below Lock 4, with its bed at the same level, i. e., 41.82 ft. Locks 1 to 4 will then be deepened by building up their walls by the following amounts, respectively, 16.40, 13.12, 16.40, and 19.68 ft.

The smallest 1 of the gates, the 29.52-ft. gate, will have to be discarded, two new gates will have to be provided, two old ones remodeled, and the final plan will be as follows:

Recess	Gate.	
1.....	72.16 ft. in height.	New.
2.....	72.16 " " "	New.
3.....	62.32 " " "	Old gate from Recess 1.
4.....	55.76 " " "	Old gate from Recess 2, reduced in height by 6.56 ft.
5.....	49.20 " " "	Old gate from Recess 3.
6.....	39.36 " " "	Old gate from Recess 4, built up by 3.28 ft.

Old 29.52 ft. gate from Recess 5 to be discarded.

This rearrangement will be as simple as could be wished, but in remodeling the lock walls they will have to be thickened, and this will necessitate the removal of a large amount of material now banked up against them, and its return after the thickening is completed.

LOCK GATES.—The Assuan lock gates are hydraulically operated, and slide back in recesses at right angles to the channel, when the lock is open. It was at first intended by the designer that the gates should be worked by hand, but the final hydraulic design is shown in Figs. 10 and 11, which are of the lower gate of the upper lock, closed.

A small turbine, in a well near the lower parapet wall, at the second buttress from the west end of the dam, operates a set of pressure pumps, which furnish 20 cu. ft. of water per hour at a pressure of 750 lbs. per sq. in. This supply is carried to two accumulators with a capacity of 8 cu. ft. each, and when the accumulators are charged the turbine is stopped automatically. Each accumulator stores enough power to make the complete movements of two gates.

From the accumulators the power is carried directly to the gate carriages, which not only support the gates, but also carry the operating mechanism by which the gates are moved, and the operating mechanism of the face valves of the gate. By this arrangement all strains from side haul are transmitted directly to the frame of the carriage, and the only side strain on the gate itself is the comparatively slight resistance

mechanism. From the seven beams of the carriage the gate proper is hung by 14 suspender rods, arranged in pairs so as to keep the gate upright under various levels of water.

Directly under the longitudinal stringers of the carriage, and supporting them, is the crate (or frame) of rollers which rests upon the bascule. The fish-belly form of the bascule beams, which are alike, and framed together, is plainly shown. The recess end of each is between two fixed beams, which carry the rollers when the gate slides into the recess in opening. The roller frames and the bascule are both pivoted just

Fig. 9. View of Emergency Curtain Used on Assuan Dam For Repairing Sluice.

within the recess (almost under the four-holed spool at the left end of the carriage), and the bascule is counterpoised. When in the position shown, the ends of the bascule rest on bed plates, the recess-end being raised slightly from its pivot by a toggle worked by a small hydraulic ram.

a unit. In addition to the four groups of sluice valves, there are four separate "scour valves" near the lower edge of the gate, each of which is operated singly.

The action of the gate is best illustrated by supposing the gate in the position shown, the upper lock full, and then following its operation in detail. Power is admitted, by levers in the box at the left end of the carriage, to the four vertical rams that operate the four groups of face-valves in the gate, and the flow from the upper to the lower lock begins through these valves. If silt has collected in the bed of the lock, and it is desired to scour it, power is admitted to the four remaining vertical rams, and the scour valves in the bottom of the gate are thereby opened. All eight of these rams are designed to make the return stroke, closing the face valves, as soon as power is cut off from them at the levers. As soon as the water surface is equalized in two locks, the face valves are shut. To accomplish the horizontal movement of the gate, power is applied to the horizontal ram shown on the carriage floor in front of the face-valve rams. This ram operates a multiplying rope which passes around a spool on the shaft at the left end of the carriage, and causes this shaft to revolve. Another rope, fixed, at its ends, to the masonry at either end of the run of the carriage, passes around the four-holed spool at the end of the shaft that is revolved by the cable from the horizontal ram. When the shaft begins to revolve, this four-holed spool hauls in on the fixed rope and the gate travels into the recess. For producing the motion in the other direction there is the other horizontal ram, which winds the shaft in the other way. The motion of the carriage has an automatic safety stop, which prevents accidents in case the operator does not shut off the power from the traveler ram at the proper point. When the carriage has reached its limit of motion into the recess, power is applied to the small ram that works the gate toggle, and the toggle lowers the weight of the left end of the bascule down onto the pivot. The hinge in the roller crate, which shows in Fig. 10, under the third floor beam from the left, is in a position nearly over the bascule pivot. Power is then applied to another ram, which raises the bascule, and with it the portion of the crate of rollers which is on the right of the hinge; the left half of the crate of rollers being left supporting the carriage and gate, on the fixed beams of the recess.

It will be seen from the above description, that the type of gate is decidedly complicated, and despite the good showing it has made, the engineer who erected those at Assuan says:

> The extra cost of the gate and masonry, and the complications in comparison with ordinary lock gates, will not, in the author's opinion, encourage the adoption of the system, except for gates of similar or larger dimensions. ["Sluices and Lock Gates of the Nile Reservoir, Assuan." F. W. S. Stokes, M. Inst. C. E. Paper 3393, Proc. Inst. C. E., Vol. 152, 1902-3, Part 2.]

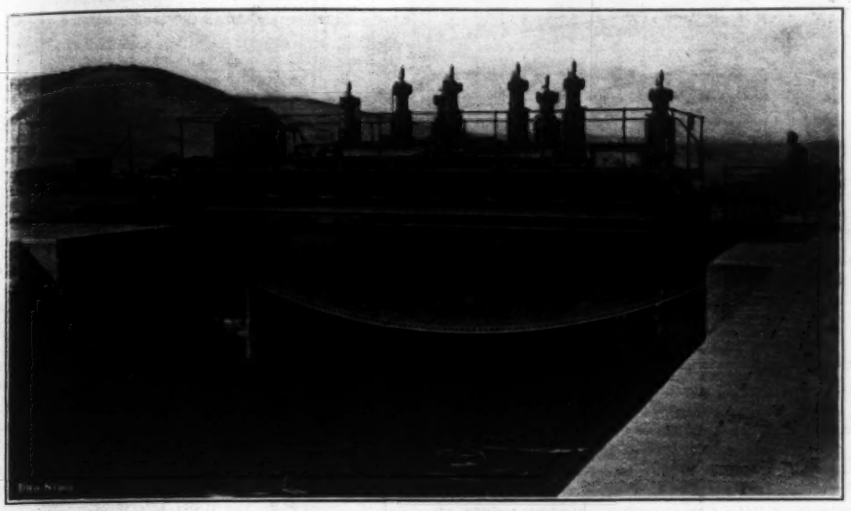


FIG. 10. UPSTREAM SIDE OF 62.3 FT. LOCK GATE ON NAVIGATION CHANNEL, ASSUAN DAM.

Fig. 10 gives a view of the gate from the recess end, and shows in addition to the features already mentioned, the walking pipe which carries the power over to the carriage for direct application.

EMERGENCY CURTAIN.—Fig. 9 shows an interesting emergency device (designed by the late Sir Benjamin Baker, and constructed by Messrs. Ransomes & Rapier) to be used in case it should become necessary to repair one of the sluice gates, or to close a sluice for any reason whatever.

This device is a heavy flexible curtain, or blind, built of "bull-head" rails with heavy strips of teak between them, strung on four steel cables. Rubber strips let into the teak make a water-tight and flexible joint, and the ends are faced with rubber for the same purpose. The curtain formed by the rails and teak strips, winds around two cast-iron disks about 4 ft. 6 ins. in diameter, fixed on a shaft, which hangs at the lower edge when the curtain is dropped. At each end of the shaft is a narrow, metal spool around which wind the cables which lower and roll up the curtain. These cables pass through apertures in the free casings of the spools, as shown in the upper right-hand part of the curtain in the view.

To bring the curtain into use, it is swung over the parapet by a large crane, and the chains on its upper edge are attached to brackets that are fixed in the masonry above the mouth of each sluice, and adjusted to the length which will bring the top of the curtain just above the edge of the sluice. The curtain is then allowed to roll down the face of the dam, into the desired position in front of the sluice mouth, by slacking away on the cables, which are at once pulled through the free casings of the spools at the ends of the roller, and wound around the spools by the weight of the descending curtain. The masonry is faced for a space of 2 ft. around the sluice-mouth, and the curtain is held against this with tremendous pressure, making a water-tight joint. After the upper end of the sluice has been thus curtained, a shield may be placed over the lower end, the sluice pumped dry, and any necessary repairs made to the interior, or to the gate.

The curtain is raised by hauling in on the cables, which, in unwinding from the spools, revolve the shaft and cause the curtain to roll up on the two cast-iron disks fixed to it. When the curtain is fully rolled up, the crane is made fast, the chains are detached from the brackets, and the roll is swung back into its cradle on the roadway.

The curtain complete weighs about 18 tons, and the crane which handles it is capable of lifting 20 tons on a radius of 25 ft. The crane runs along rails bolted to the top of the two parapet walls, and is provided with a telephone, small electric light plant, air compressor, and a small diving bell, which may be lowered into the reservoir to make examinations and to remove rocks and other obstructions from in front of the sluices. The writer believes that except in tests this apparatus has had but little use.

In Fig. 9 the chains in the fore and background, to the left, serve to hang the upper edge of the curtain to the brackets over the sluices. The steel cable at the near end, and a similar one at the opposite end of the curtain, run through the spool casings as shown, and roll up the curtain. The flat surface back of the casing is the outside of one of the iron disks on the shaft, around which the curtain rolls. The general section of the strips of teak and the "bull-head" rails may be easily noted at the end of the curtain. To the right is the parapet wall, with the rails of the crane track bolted to it. In the foreground, and stretching away in the background, in a line beside the wall, and behind the curtain, are the gearings for raising the sluice gates.

SLUICES AND SLUICE GATES.—The sluiceways of the heightened dam will not differ from, and will be simple extensions of, those of the original; they will be carried through the masonry of the reinforcement in each case in the same manner in which they were carried through the original structure.

The original dam is pierced by 180 sluices of rectangular section, with bell-mouths. The bell-mouths are domed with cast-iron lintels, and 30 of the large sluices at an elevation of 56.58 are lined with cast iron built in flanged sections, bolted together, and built into the dam as it was carried up. In all other sluices ashlar linings were used, and have proved perfectly satisfactory. The ashlar of the linings is 2.2 ft. thick. All the lintels are 8.86 ft. long, giving a lap on each end of 1.15 ft. The sills are of such length as to give alternate half and full spans, the full length stones being 8.20 ft. long.

The sluices are arranged in sets of ten, ordinarily, the extreme range in number being eight small sluices in Set No. 16, and twelve small sluices in Set No. 18 (adjoining the "solid" portion of the dam). Sets Nos. 7 and 8 are split sets, containing five small sluices at a level of 97.58 and five large sluices at a level of 71.34 in each set.

One hundred and forty of the sluices are large—22.96 × 6.56 ft.—and 40 are small—11.48 × 6.56 ft. Between each set of sluices and the succeeding set comes a buttress, and these buttresses are spaced 246 ft. apart, uniformly throughout the length of the "pierced" dam. The sills of the sluices are at the four levels, as follows:

22 Small sluices, at 97.58 ft.
18 Small sluices, at 84.46 ft.
75 Large sluices, at 71.34 ft.
65 Large sluices, at 56.58 ft.

Of the 180 sluices, 100 large and 30 small are designed to work under considerable head in regulating the water in the reservoir, and are, therefore, fitted with Stoney balanced roller gates. The remaining 50 gates, 10 small and 40 large, are only used in flood times, and are fitted with simple slide gates, since they are worked under but small heads. The large gates at the 56.58-ft. level have a head of 60.68 ft. over the sill, and sustain at present a pressure of nearly 210 tons. When the dam is heightened, this head will be increased to 93.64 ft., and the pressure to nearly 325 tons.

Materials and Labor.

The dam is built of the red granite of Assuan, laid in Portland cement mortar. On the upstream face, and for a distance of 2.2 ft. above the bottom of the rest of the dam, the masonry is laid in 1:2 mortar, and in the core of the dam and on the lower side in 1:4 mortar.

The weight of the stone is recorded as 143.5 lbs. per cu. ft., and the weight of the masonry laid in 40% of 1:4 mortar, as 149.5 lbs. per cu. ft. The large amount of masonry in the apron is also laid in 1:4 mortar.

In the cool weather the dam shows moisture on the down-stream side, but the masonry is perfectly secure, and the leakage seems to be confined solely to a little "sweating." In hot weather this moisture entirely disappears.

The dimension stones and ashlar facings are quarried from the Assuan quarries, near Shellal, on the east bank of the Nile, just above the dam. Part of the rough rubble filling comes from the same place, and part has been quarried from the islands in the river channel directly below the dam. The majority of the drillers are native Egyptians, and "piece work" has been applied successfully. The masons and finishers of the ashlar and facings, are nearly all Italians imported from the north of Italy. It has been found that they stand the climate better than British laborers, both on account of their previous environment and on account of their more abstemious habits.

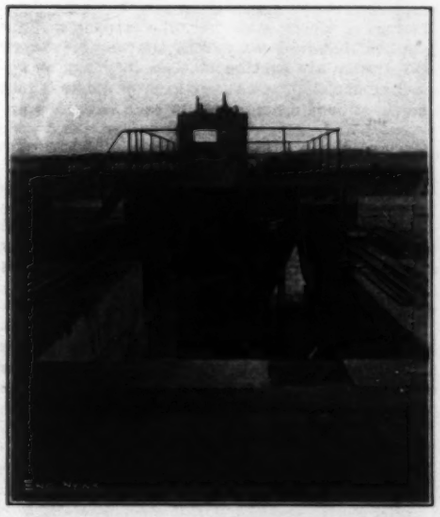


Fig. 11. Side View of Lock Gate Looking Toward Channel. Assuan Dam, Egypt.

The sand used in the mortar is brought down the reservoir in barges, from a point between the Shellal quarries and the dam and then carried over the top of the dam by native porters, and dumped down chutes, which lead it to the desired point on the work below.

The cement is all imported, of course, and may be brought up the river in barges or brought

up the railroad to Luxor, trans-shipped to the narrow-gage and brought to Shellal. From there it may be distributed to the work as is most convenient, to the lower side by construction tracks, or to the upper by barges, through the reservoir.

When the full force is at work there are between 3,000 and 4,000 men on the construction, quarrying out the foundation, carrying mortar and material, and placing rock. At such times the place resembles an ant's nest more than anything else, but the work seems to be economically and rapidly accomplished.

At the beginning of the present flood season the addition to the "solid" section is finished to the top of the old dam, the addition to the "pierced" section is up to the level for about one-third of the entire length of the dam, extending out from the navigation channel, and the intervening reinforcement should now be above the level of flood waters below the dam. It is estimated that it will take about three more years to complete the work.

The half-tone views shown herewith are from photographs taken by the writer in February, 1909, and the line drawings are based on originals found in the official publications of the Egyptian Department of Public Works, Cairo. The writer wishes to express his most hearty thanks to Mr. A. McCorquodale, Resident Engineer, and to Mr. P. H. East, of the engineering staff, for kindness and courtesies extended to him and for information furnished him, while at Assuan Dam.

Moments in Continuous Reinforced-Concrete Beams Under Uniform Loading.

By R. E. SPAULDING.*

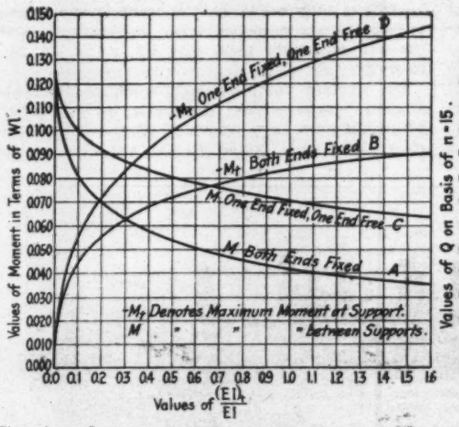
Much has been written about the advantages gained in a monolithic reinforced-concrete structure because of its continuity. Building codes require, however, that continuous or fixed-end beams be figured for a bending moment of Wl/8, or in a very few cases Wl/10, this being between supports, little provision being made for proportioning reinforcement over the supports. The practical builder asks: Why, if concrete beams and girders are continuous, can they not be figured as such? The answer usually given is that the exact bending moments in such cases are unknown, and gives the impression that the stresses in a continuous concrete girder cannot be so readily determined as in an ordinary continuous beam. Such is not the case, since the bending moments, both between supports and over supports, can be easily determined if the conditions as to reinforcement and nature of supports be known. The following is a general solution of such a case, with formulas which may be applied to any similar concrete beam.

Fig.1.

The old and well known continuous-beam formulas do not apply to continuous concrete beams for the reason that the stiffness factor (EI) is not constant in a concrete beam. The stiffness factor varies (1) because of the difference in reinforcement over supports and between supports, and (2) because of the T-section usually employed. Fig. 1 shows a side elevation and two cross-sections of such a beam. The neutral axis of the mid-section has a position $n - n'$ depending upon the percentage of steel used. We have then for compression the shaded portion of this section. Now taking a section over the support we have for compression the shaded portion below the neutral axis $m - m'$. Since all tension in concrete is neglected it is evident that the moments of inertia of the two sections are quite different. It may be also seen that these moments of inertia are constant between points of contraflexure, but change abruptly at that point. This gives us a basis for calculations.

Fig.2.

*210 West St., Worcester, Mass., Instructor in Civil Engineering, Worcester Polytechnic Institute.


Values of Moment in Terms of Wl.
Values of (EI)t/EI
-Mt One End Fixed, One End Free D
-Mt Both Ends Fixed B
M. One End Fixed, One End Free C
M Both Ends Fixed A
-Mt Denotes Maximum Moment at Support.
M " " " between Supports.
Fig. 4. Curves of Maximum Bending-Moments in Beams With Different Moments of Inertia at End and Center.

M_t = moment over support.
M = maximum moment between supports.
Ordinates give moments in terms of Wl.

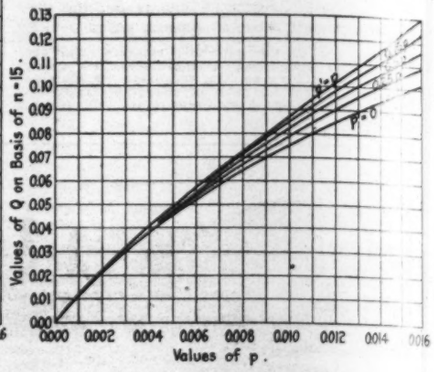


Fig. 6. Curves for Computing Ratio of Moments of Inertia in Reinforced-Concrete Beams.

For different percentages of tension reinforcement and for five ratios of compressive reinforcement,
p = tension reinforcement percentage.
p' = compressive reinforcement percentage.
Ordinates give values of Q in formulas

$$I = Q\,bd^3,$$

and $$\frac{(EI)_t}{EI} = \frac{Q_t b_t d_t^3}{Q\,b\,d^3}.$$

Curves computed for $\frac{E_s}{E_c} = 15$.

Taking a built-in or fixed-end beam, as in Fig. 2, let

l = distance between supports.
$(EI)_t$ = stiffness factor at support to point of contraflexure.
(EI) = stiffness factor between points of contraflexure as indicated.
v = distance from support to point of contraflexure.
S = shear on section at point of contraflexure.
x = distance from left support to point under consideration.
w = load on beam per unit length (load assumed uniform).
M_t = maximum bending moment at support.
M = maximum bending moment between supports.

We then have for moment equation between points of contraflexure

$$E\,I\frac{d^2y}{dx^2} = S\,(x-v) - \frac{w\,(x-v)^2}{2} \qquad (1)$$

But we know $S = \frac{1}{2}\,wl - wv$; hence

$$E\,I\frac{d^2y}{dx^2} = \frac{1}{2}\,w\,(lx - l\,v + v^2 - x^2) \qquad (2)$$

Integrating (2) we obtain the equation of the slope of the elastic curve as

$$E\,I\frac{dy}{dx} = \frac{1}{2}\,w\left(\frac{1}{2}lx^2 - lvx + v^2x - \frac{x^3}{3}\right) + C \qquad (3)$$

We know that at $x = \frac{1}{2}\,l$ the slope is equal to zero. Then putting $x = l/2$ in (3) and solving for C we obtain

$$C = \frac{1}{4}\,w\,(v\,l^2 - v^2\,l - \frac{1}{6}\,l^3)$$

and (3) becomes

$$E\,I\frac{dy}{dx} = \frac{1}{2}\,w\left(\frac{1}{2}lx^2 - lvx + v^2x - \frac{1}{3}\,x^3 + \frac{1}{2}\,v\,l^2 - \frac{1}{2}\,v^2\,l - \frac{1}{12}\,l^3\right) \qquad (4)$$

As a moment equation between support and point of contraflexure we have

$$(E\,I)_t\frac{d^2y}{dx^2} = S\,(x-v) - \frac{w\,(v-x)^2}{2} \qquad (5)$$

or, since $S = \frac{1}{2}\,w\,l - w\,v$, as before, we get

$$(E\,I)_t\frac{d^2y}{dx^2} = \frac{1}{2}\,w\,(lx - l\,v + v^2 - x^2) \qquad (6)$$

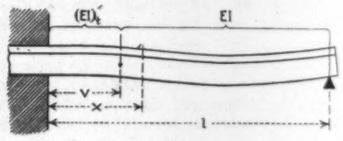


Fig.3.

Integrating (6) to obtain the equation of the slope,

$$(E\,I)_t\frac{dy}{dx} = \frac{1}{2}\,w\left(\frac{1}{2}\,lx^2 - l\,vx + v^2\,x - \frac{1}{3}\,x^3\right) + (C = 0) \qquad (7)$$

$C = 0$, for when $x = 0$, slope $= 0$.

We know that at $x = v$ the slope of (4) equals the slope of (7); then putting $x = v$ in (4) and (7), and equating these slopes,

$$\frac{\left(\frac{2}{3}\,v^3 + \frac{1}{2}\,v\,l^2 - v^2\,l - \frac{1}{12}\,l^3\right)}{EI} = \frac{\left(\frac{2}{3}\,v^3 - \frac{1}{2}\,l\,v^2\right)}{(E\,I)_t} \qquad (8)$$

whence

$$\frac{(EI)_t}{EI} = \frac{8\,v^3 - 6\,v^2\,l}{8\,v^3 - 12\,v^2\,l - 6\,v\,l^2 - l^3} \qquad (9)$$

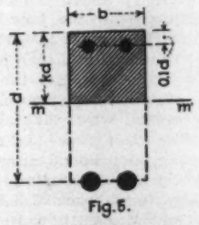


Fig.5.

We know that the moments at the support and at the center are

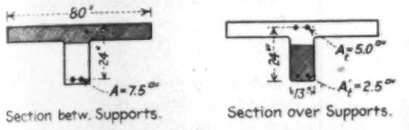
$$M_t = \frac{1}{2}\,w\,(v^2 - v\,l) \qquad (10)$$

and

$$M = \frac{w\,l^2}{8} + M_t \qquad (11)$$

By using the last three equations to compute values of EI_t/EI, M, and M_t for various values of v, and plotting values of $\frac{(EI)_t}{EI}$ as abscissa with corresponding values of M and M_t as ordinates, we obtain curves A and B, Fig. 4, showing the relation between the ratio of stiffness factors over supports and between supports and the corresponding maximum bending moments. When $(EI)_t$ and EI are known, the values of M_t and M are readily determined. For instance it is seen from Fig. 4 that when $\frac{(EI)_t}{EI} = 0.3$, $M_t = M = \frac{1}{16} Wl$; also that when $\frac{(EI)_t}{EI} = 1.0$, $M_t = \frac{1}{12} Wl$ and $M = \frac{1}{24} Wl$.

If all concrete beams had rigidly fixed ends no further work in this direction would be necessary, but unfortunately such is not the case. Evidently in a building having very heavy columns, the girders entering these columns on the lower floors would have practically fixed ends. In some other cases, as in roof girders, this would be very doubtful except in case of a large number of equal spans. The extreme case in ordinary construction would seem to be equivalent to having one end rigidly fixed and the other end free to turn about its point of support. This



Section betw. Supports. Section over Supports.

Fig.7.

case is shown in Fig. 3. In a manner quite similar to the analysis above outlined, we obtain for this case,

$$\frac{(EI)_t}{EI} = \frac{v^4 - 4v^3 l + 6v^2 l^2}{v^4 - 4v^3 l + 6v^2 l^2 - 4v l^3 + l^4} \qquad (12)$$

$$M_t = -\frac{v l}{2} w \qquad (13)$$

$$M = \frac{(l-v)^2}{8} w \qquad (14)$$

Combining and plotting as before we obtain curves C and D, Fig. 4, which give us at once (when the ratio of the stiffness factors is known) the maximum bending moments for this extreme case both between supports and over the fixed support, under the assumed conditions.

It seems safe to assume that the maximum bending moments between supports will, in ordinary monolithic construction, lie between lines A and C of Fig. 4. Then for any given ratio of stiffness factors the maximum moment can be at once determined.

In both the foregoing cases the assumption is made that the amount of reinforcement steel is constant between points of contraflexure. This is not strictly true, but the deviation from this in the ordinary beam is not sufficient to affect the values to any appreciable extent.

To determine the stiffness factor (Fig. 5) let

d = depth of beam, from compressive face to center of gravity of tensional steel.
kd = depth from compressive face to neutral axis $m - m'$.
b = breadth of compressive face of beam.
n = ratio of modulus of elasticity of steel to modulus of elasticity of concrete, E_s/E_c.
A = sectional area of tensional steel.
A' = sectional area of steel in compression.
p = steel ratio A/bd of steel in tension.
p' = steel ratio A'/bd of steel in compression.

Expressing the modulus of elasticity of steel in terms of that of the concrete, $E_s = nE_c$ or simply nE.

The moment of inerita of the compressive concrete about axis m—m' will be

$$\frac{1}{3} b (kd)^3$$

The moment of inertia of the tensional steel about the same axis will be

$$A \times n (d - kd)^2$$

and the moment of inertia of the compressional steel

$$A' \times n \left(kd - \frac{d}{10}\right)^2$$

Thus we have

$$(EI) = E\left[\frac{1}{3} b (kd)^3 + A n (d - kd)^2 + A' n \left(kd - \frac{d}{10}\right)^2\right] \qquad (15)$$

Taking $A = pbd$ and $A' = p'bd$ we have

$$(EI) = E b d^3 \left[\frac{1}{3} k^3 + p n (1 - 2k + k^2) + p' n (k^2 - 0.2k + 0.01)\right] \qquad (16)$$

Or denoting the quantity in brackets by Q for simplicity, we have

$$(EI) = E b d^3 Q \qquad (17)$$

Then

$$\frac{(EI)_t}{EI} = \frac{b_t d_t^3 Q_t}{b d^3 Q} \qquad (18)$$

In Fig. 6 will be found curves giving values of Q for all percentages of tensional reinforcement up to 1½%, and for $p' = 0$, $p' = \frac{1}{2} p$, $p' = \frac{1}{4} p$, $p' = \frac{3}{4} p$, and $p' = p$.

Then to find the relative stiffness factors all that is necessary is to look up on this curve sheet the abscissa corresponding to the percentage of tensional reinforcement used, and from the proper curve above, the ordinate corresponding gives directly the value of Q. This multiplied by bd^3 gives the desired function of EI. The values over supports and between supports being found, the ratio $\frac{(EI)_t}{EI}$ is determined at their quotient.

With this last quantity, and the curved diagram, Fig. 4, the maximum bending moments are readily found.

EXAMPLE.—As an illustration assume a T-beam whose stem is 13 ins. wide; $d = d_t = 24$ ins.; effective width of flange between supports = 80 ins. (Fig. 7).

The areas of reinforcement are $A = 7.5$; $A_t = 5.0$; $A_t' = 2.5$; from which we find the percentages to be

$$p = \frac{7.5}{24 \times 80} = 0.0039$$

$$p_t' = \frac{1}{2} p_t$$

$$p_t = \frac{5.0}{24 \times 13} 0.016.$$

From Fig. 6 we find $Q = 0.037$, and $Q_t = 0.116$. Then by equation (18)

$$\frac{(EI)_t}{EI} = \frac{b_t d_t^3 Q_t}{b d^3 Q} = \frac{b_t Q_t}{b Q} = \frac{13 \times 0.116}{80 \times 0.037} = 0.510$$

Then by the curves of Fig. 4 we find that if the beam be considered as having fixed ends,

$$M = \frac{1}{19} W l$$

$$M_t = \frac{1}{14} W l$$

If only one end be considered fixed,

$$M = \frac{1}{12.5} W l$$

$$M_t = \frac{1}{10} W l$$

Then the probable limits would be

$$M = \frac{1}{19} \text{ to } \frac{1}{12} W l$$

$$M_t = \frac{1}{14} \text{ to } \frac{1}{10} W l$$

In which case the strength of concrete in bending over the support would undoubtedly limit the safe load on the beam.

If the tensional reinforcement over the support be cut in half, $Q_t = 0.072$, and

$$\frac{(EI)_t}{EI} = \frac{13 \times 0.072}{80 \times 0.037} = 0.31$$

Then for both ends fixed,

$$M = \frac{1}{16} W l, M_t = \frac{1}{16} W l;$$

for only one fixed end,

$$M = \frac{2}{23} W l, M_t = \frac{1}{12} W l;$$

showing less steel over the support with no more steel added between supports to be economical, but the strength of the beam still being limited by the compressive stress in the concrete over the support.

If the tensional steel over supports be still further reduced to one-fourth of the original amount, or 0.125 sq. in., other conditions remaining the same, $Q_t = 0.043$ and

$$\frac{(EI)_t}{EI} = \frac{13 \times 0.043}{80 \times 0.037} = 0.175$$

Then for a beam with both ends fixed,

$$M = \frac{1}{14} W l, M_t = \frac{1}{19} W l;$$

for only one end fixed,

$$M = \frac{1}{10.75} W l, M_t = \frac{1}{14.7} W l;$$

in this case also the stresses over the supports limit the safe load.

From the numerous cases the writer has had occasion to work out at different times it seems to be uneconomical to try to build ordinary T-beams for a bending moment of 1/10 Wl between supports, but rather to proportion the reinforcement there for ⅛ Wl as with a simple beam, and then put enough steel over the supports to produce the desired continuity of the structure without inducing excessive bending moments at that point. The object of this arrangement is to make as stiff a section as possible between supports, so as to prevent excess flexure at that point and consequent bending and induced moment over supports. In many cases on actual construction even when beams were figured on a basis of $M = \frac{1}{8} Wl$, so much steel was used over the supports that under the above analysis it was evident that the concrete in the lower part of the stem over the supports was worked far above the allowable stress, while the materials between supports were not developing the figured stresses. If these had been built upon a basis of $M = 1/10\ Wl$ the evil effects would have been even worse.

The results of the above analysis as well as various other considerations, such as uncertainties of uniform load over a number of supports, unequal settlements of the supports, unequal spans, non-rigidity of supports, uncertainty of effective flange width, etc., would seem to show that it is both impractical and uneconomical to design ordinary continuous reinforced-concrete beams or girders for a lower bending moment than that in a simple beam (not continuous) under the same conditions of loading and span.

THE TWO 26,000-TON U. S. BATTLESHIPS for which bids were opened a few weeks ago, according to a recent decision of the Board of Construction are to be equipped with Parsons turbines.

The Application of the Traverse Method to Railroad Curve Problems.

By WM. CLYDE WILLARD.*

The majority of field manuals make no application of the Traverse Method to the solution of railroad curve problems. This may be due to the simplicity of the method, or possibly to the fact that in some cases it cannot be used and in others it means additional work. However, it will be found in general that in solving a problem by the traverse method a large saving in time and labor will result. The objection often expressed to its use is that the centers of the curves must be occupied by the instrument, thereby greatly increasing the field work. Such a criticism is due to ignorance, since in no case is this ever necessary. The application of this method to the solution of several curve problems is given below. In a subsequent article will be given an explanation of the Southern Pacific Taper Curve Tables and a solution by the traverse method of several general problems illustrating their use. The traverse method is applicable to other transition curves as well.

An explanation of the principles employed in the solution of traverses may be found in all books on plane surveying. In the following article the relation of the traverse to curve problems will be shown by the solution of several general problems. Those given will serve to show the method of application so that a brief study of any other problem will show if this method is applicable and if so, how to apply it. By assuming the bearing of

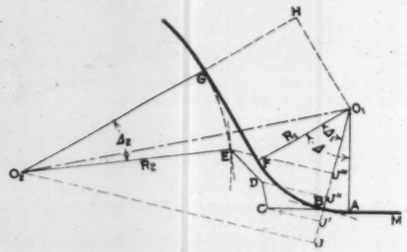


Fig. 1.

one course of the traverse as either north or south one co-ordinate becomes zero, thereby simplifying the solution.

A. Given two curves on the ground exterior and reverse to each other, to find the tangent points and the length and direction of a line tangent to both curves. (Fig. 1).

Let $A\,F$ and $E\,G$ be the two curves, centers O_1 and O_2, and $F\,G$ the required tangent. Draw O_1H equal and parallel to $F\,G$.

From any point such as B on the first curve run a traverse $B\,C\,D\,E$ to any point E on the second curve. Measure deflection angles at C and D and angles between first and last course of traverse and tangent to curve at B and E. The radii of the curves are known, R_1 and R_2. Assume bearing of $O_1\,B$ as north. Then in the traverse $O_1\,B\,C\,D\,E\,O_2$ everything becomes known but length and bearing of closing side $O_2\,O_1$. Solve for these. Produce $O_1\,B$ to J and the co-ordinates of the traverse points are $O_2\,J$, $J\,O_1$; $C\,J'$, $J'\,O_1$; etc.

$$\tan J\,O_2\,O_1 = \frac{O_1\,J}{J\,O_2}, \qquad O_2\,O_1 = J\,O_2 \csc J\,O_2\,O_1.$$

In the right triangle $O_1\,H\,O_2$, lengths $O_2\,O_1$ and $H\,O_2$ ($H\,O_2 = R_1 + R_2$) are known.

Then,
$$\cos O_1\,O_2\,H = \frac{H\,O_2}{O_2\,O_1}.$$

Bearing $O_1\,J$ was assumed north. Angle $J\,O_2\,O_1$ was found from the traverse and angle $O_1\,O_2\,H$ from triangle.

$$\therefore\ \Delta_1 = 90^\circ - (J\,O_2\,O_1 + O_1\,O_2\,H),$$

fixing the tangent point F and the direction of the unknown tangent $F\,G$. The tangent length is

$$F\,G = O_1\,H = O_2\,O_1 \sin O_1\,O_2\,H$$

*Construction Department, Southern Pacific Railroad.

The second tangent point G is fixed as a check by

$$\Delta_2 = J\,O_2\,O_1 + O_1\,O_2\,H - J\,O_2\,E.$$

If $A\,M$ is the last preceding tangent, the traverse may be started at A when convenient, and $\Delta = \Delta_1$.

Transition curves may now be run in by offsetting the curves.

B. Given two curves exterior to each other, curving in the same direction, to find the tangent points and the length and direction of a line tangent to both curves. (Fig. 2.)

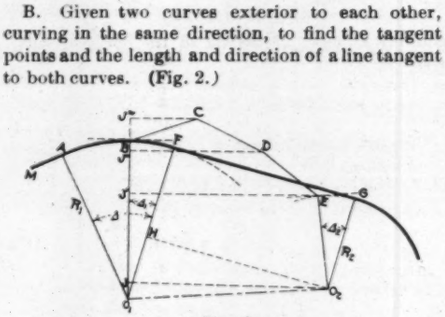


Fig. 2.

The construction is similar to that in A. From any point such as B on the first curve run a traverse $B\,C\,D\,E$ to any point E on the second curve, measuring angles as above. Assume bearing of $O_1\,B$ as north. Then in the traverse $O_1\,B\,C\,D\,E\,O_2$ everything becomes known but the length and bearing of the closing side $O_2\,O_1$. The coordinates of O_2 reckoned from O_1 are $O_1\,J$ and $J\,O_2$.

$$\tan J\,O_2\,O_1 = \frac{O_1\,J}{O_2\,J}.$$

Length $O_2\,O_1 = O_2\,J \csc J\,O_2\,O_1$.

Drawing line $O_2\,H$ parallel to the tangent $F\,G$, in the right triangle $O_1\,H\,O_2$ we have $O_2\,O_1$ known and $O_1\,H = R_1 - R_2$. Then

$$\sin H\,O_2\,O_1 = \frac{H\,O_1}{O_2\,O_1}, \text{ and } H\,O_2 = F\,G = O_2\,O_1 \cos H\,O_2\,O_1$$

$$\Delta_1 = H\,O_2\,O_1 - J\,O_2\,O_1.$$

The bearing of $O_1\,F$ now becomes known and point F is fixed.

It is seen that the solutions for the two preceding problems are practically the same. They are rigorously exact, while in many field manuals, as Searles', the solution given for these problems involve approximations.

C. Given a tangent of indefinite length, fixed on the ground, to find a point on the tangent from which a curve of given degree may be run through a fixed point not on the tangent, so as to end in a tangent which shall pass through a second fixed point. (Fig. 3.)

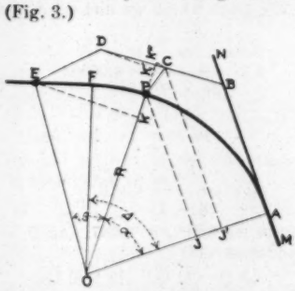


Fig. 3.

Let $M\,N$ be the fixed tangent of indefinite length,
P = fixed point through which curve must pass,
E = fixed point through which final tangent must pass.

From some point on the fixed tangent near P (such as B) run a traverse $B\,C\,D\,E$ to the farther fixed point E. From C measure angle and distance to fixed point P. If $C = 90^\circ$, the numerical work is shortened.

The length $O\,A = R$ being given, assume the bearing of $O\,A$ as south. In the traverse $O\,A\,B\,C\,P$, all quantities are known except length $A\,B$ and bearing of the closing side $P\,O$. Solve for these; the difference between the plus and minus latitudes gives the latitude of P, equal to $O\,J$, and therefore the triangle $O\,J\,P$ becomes known since $O\,P = R$ and $O\,J$ is known.

$\cos P\,O\,J = \dfrac{O\,J}{P\,O}$, giving bearing of $P\,O$ and therefore, angle α.

$J\,P$ = longitude of $P = P\,O \sin P\,O\,J$.

The longitudes of all courses except $A\,B$ are known from this, so that the difference between the plus and minus longitudes gives the longitude of B, which is equal to length $A\,B$, and the $B.\,C.$ becomes fixed.

In the traverse $O\,P\,C\,D\,E$ all quantities are known except length and bearing of $E\,O$.

Assume bearing of $O\,P$ as north and solve for these. Having found them, in the triangle $E\,F\,O$, the lines $E\,O$ and $F\,O = R$ are known. The other quantities are found by

$$\cos E\,O\,F = \frac{F\,O}{E\,O} \text{ and } E\,F = E\,O \sin E\,O\,F.$$

The angle α was found from the first traverse, angle β from the second, and angle $E\,O\,F$ from triangle $E\,F\,O$.

Then,
$$\Delta = \alpha + \beta - E\,O\,F,$$

and the position of point F, or $E.\,C.$, and direction of tangent $F\,E$ through fixed point E become known.

Tunneling Progress in Clay, with Excavating Machines and with Ordinary Shields.

Tunneling by machine excavators is noted by Mr. Francis Fox, M. Inst. C. E., in a paper on underground railways, prepared for the 1910 meeting of the International Railway Congress. He refers to the Price electrical machine, which was illustrated and described in our issue of Dec. 19, 1907. In the three London underground railways noted in the table below, the machine excavated the full section, but in the Rotherhithe highway tunnel (under the Thames) it excavated a 12½-ft. pilot tunnel in advance of the full 30-ft. section.

Mr. Fox states that the machine is able to advance 1 in. per minute through the London clay, and that a ring of 20 ins. has been advanced in an hour. The number of men is given as 13 for working with an ordinary shield; with the excavator only 8 men are required, and these have to attend chiefly to keeping up a supply of empty skips, removing the loaded cars, and cleaning up. A distinct improvement in the air of the tunnel is perceptible wherever the electrical excavator is at work; this is considered due to the reduced number of men and the less arduous character of their work, and in some measure also to the employment of electricity.

The figures of progress by the Price machine and by ordinary shields are given in the accompanying table. The work in the underground railway tunnels was done mainly in free air, with 11 shifts of 10 hours each per week. The work in the pilot tunnel was done under compressed air, with 17 shifts of 8 hours each per week.

TABLE OF TUNNEL PROGRESS WITH EXCAVATING MACHINES AND WITH SHIELDS.

	External diam. of c. i. lining, ft.	ins.	No. of 20-in. rings fixed.	No. of weeks.	Ave. per week for all tunnels.	Ave. per week for best tunnel.	Max. No. of rings in one week.
With Price Excavator:							
Gt. Nor., Piccadilly & Brompton Ry	12	6	8,613	177	49	75	
Gt. Nor., Piccadilly & Brompton Ry. (on sharp curves)	13	4¾	5,347	121	44	76½	
Ch. Cross, Euston & Hampstead Ry	12	6	18,450	384	48	71½	
Rotherhithe (highway); pilot tunnel (in compressed air)	12	6	791	14	56½	..	
With Ordinary Shields in Free Air:							
Gt. Nor., Piccadilly & Brompton Ry	12	6	18,661	611	30½	40	
Ch. Cross, Euston & Hampstead Ry	13	4¾	6,695	307	22	30½	

Some Concrete Culverts and Small Bridges on the Slateford-Hopatcong Cut-Off of the Delaware, Lackawanna & Western R. R.

On the new Slateford-Hopatcong cut-off of the D., L. & W. R. R. (Eng. News, Aug. 13, 1908, p. 176) now in the course of construction there are some 90 locations where a small stream or a highway has to be crossed, in the majority of cases on overhead structures. For all of these crossings except one, concrete is being used, and a general arch type has been designed which, with modifications to suit local conditions, is employed in the majority of cases. In addition, where the clearance is limited, there has also been designed a flat-slab type. In the present article are given the drawings of one of each of these types and some views of typical structures taken in August of the present year.

Combined Concrete Highway Arch and Culvert.

At Vail, N. J., there has been built a combined highway arch bridge and culvert, known as the Molasses Junction arch, which is one of the longest on the line and, in its details, is fairly typical of this form of construction at other points along the cut-off. Here, as at a number of other places, there is a very high and long fill across a deep valley through which passes a highway and a small stream of water. Though originally the highway and the stream were not adjacent, they have been brought together near the fill so that the two could be led under it in the same structure, thus saving considerable expense. The grade of the top of the fill is about 95 ft. above that of the highway, which, with the tailing slope of 1 on 1½, required a length of arch of 273 ft. between portals.

The details of the Molasses Junction arch are shown in Figs. 1-2. It consists of an arch with 22-ft. inside diameter, under one side of which is a flat-topped culvert, 4 ft. high and 8 ft. wide. From the end to the middle, the arch is divided into three sections of different lengths, in each of which the thickness of the arch ring and consequently the total outside width of the arch is dimensioned according to the amount of fill, so that these two dimensions increase from the end toward the center. Thus the end section has a crown thickness of 24 ins. and a total width at base of abutments of 48 ft. 9 ins., while at the middle these dimensions are 36 ins. and 60 ft. 9 ins., respectively.

The arch ring is reinforced throughout by the same amount of steel, regardless of the concrete dimensions, viz., longitudinal ¾-in. sq. bars, 2 ft. c. to c., continuous from portal to portal, so bent up at each change of section as to be a fixed 3 ins. from the ring surfaces. There is no transverse reinforcement. All continuous bars are lapped 40 times their least diameter.

The culvert, which is fully explained by the section in Fig. 2, is an integral portion of one abutment, built at the same time as that abutment and joined into it by reinforcement. Its slab top is reinforced with a set of transverse and longitudinal bars. In this particular structure the culvert enters and leaves the arch on the same side, following, at each portal, the line of the wing wall, but in some of the arches topographical conditions required that the culvert cross the arch transversely. In these cases the culvert enters as in the Molasses Junction arch, follows along the one side of the arch to the opposite portal, and there crosses under the highway to the opposite wall, which it follows to its own portal just beyond the highway line. The arrangement of the portal is best shown in the half-tone in Fig. 3, which is a view of the Ramsey Fill

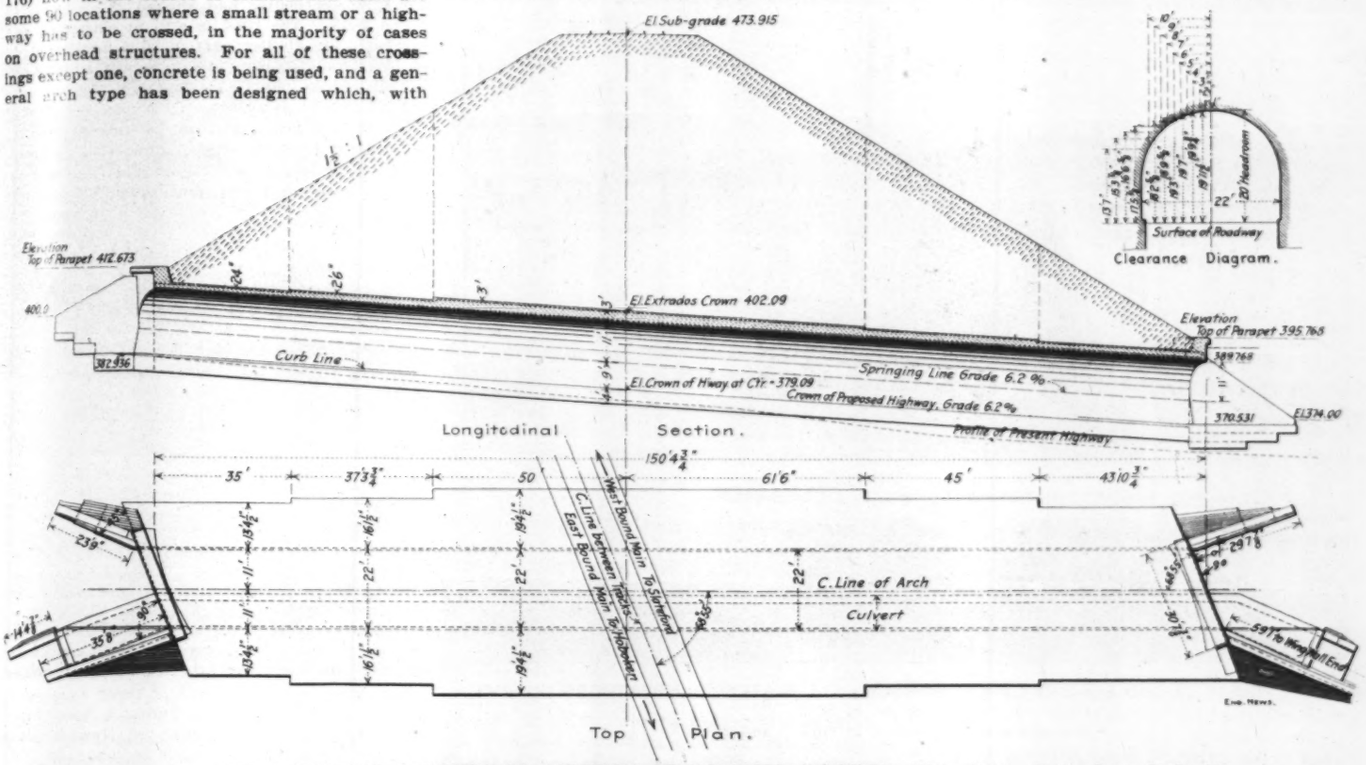
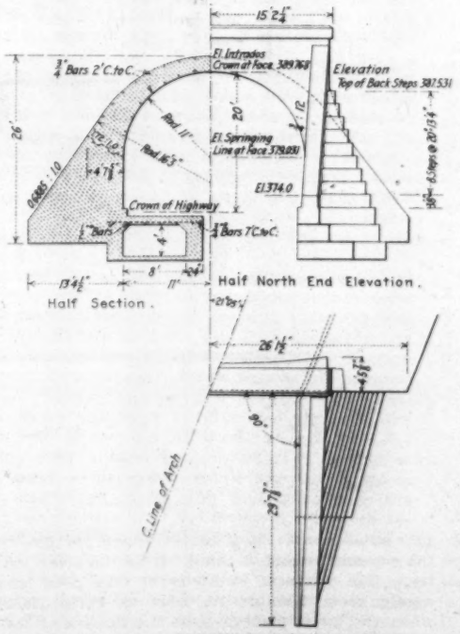


FIG. 1. PLAN AND LONGITUDINAL SECTION OF MOLASSES JUNCTION, VAIL, N J. D. L. & W. R. R.



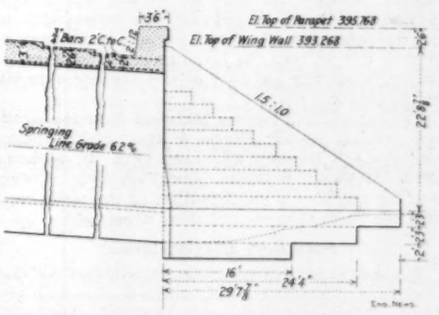


FIG. 2. DETAILS OF MOLASSES JUNCTION ARCH.

inner ledge shown in the figure vertical frames are erected which carry the arch centers. These lower frames move on the ledge on rollers, so that as the work of concreting the arch ring progresses, the lower frames are rolled along, to support the arch centers which are taken down from the rear of the work and moved through the arch up to the front of the work as needed. In this way a comparatively short length of forms was needed for the 273-ft. barrel. Work was carried on throughout the winter. During this low temperature period the ring concrete was allowed to set 30 days before moving the forms. As noted above, these arch forms start just above the spring so that when they are dropped they do not scratch or scrape the side walls.

No real expansion joints have been placed in

this long arch. However, it was figured out that the contractor could lay in one day about 16 lin. ft. of arch ring, so that at the end of each day's work there was a cut made clear through the arch ring concrete. As the steel reinforcing is continuous throughout the barrel, this expansion joint is not complete.

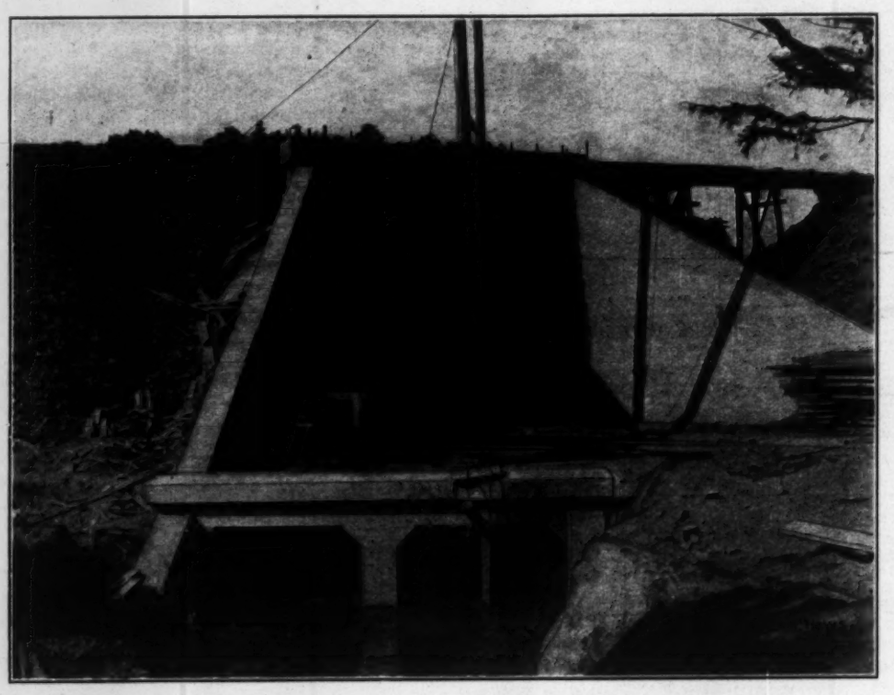


FIG. 3. CULVERT AND ROADWAY ARCH, RAMSEY FILL; SLATEFORD-HOPATCONG CUT-OFF, D. L. & W. R. R.
(Not the Structure Shown in Figs. 1 and 2.)

Most of the footings for the arches of this type are on solid rock or gravel, but the arch shown in Fig. 3 is on very soft ground, so that it was necessary to drive piles under the footings for both the main arch and the culvert, and construct an invert of reinforced concrete between abutments.

All structures on the Cut-off were designed for a live load of Cooper's E 50 standard loading with impact plus the entire dead load of fill vertically above the arch, that is, no arching action was assumed through the fill. All except one of the heavy fills along the cut-off are made with a poorly-laminated slate rock, usually taken from a nearby cut, so that the loadings are exceptionally heavy, especially as most of the fills are over 50 ft. in height.

The contractors for the Molasses Junction Arch are Messrs. Reiter, Curtis & Hill, Philadelphia, and for the Ramsey Fill arch (Fig. 3), Messrs. Hyde, McFarlin & Burke, New York City. These bridges are only a small portion of the large section contracts that each of these firms hold.

Slateford Flat Culvert.

The flat culvert type is best illustrated by the structure at Slateford, Pa., which is shown in detail in Fig. 4, and in the view in Fig. 5. Here the elevation of the track rail was so close to that of the creek that sufficient clearance could not be gained with the arch type of culvert. The construction is quite clearly explained on the drawing. There is nothing in it of remarkable novelty, except perhaps the slab floor for the creek to run over, but it is a very good example of simple and efficient design. The culvert is on the contract of the Smith-McCormick Co., of Easton, Pa.

The structures on this line were designed under the direction of Mr. L. Bush, M. Am. Soc. C. E., up to a short time ago Chief Engineer of the railroad, and of Mr. G. J. Ray, M. Am. Soc. C. E., at present Chief Engineer. They were designed in the office of Mr. B. H Davis, Assistant Engineer, and are being built under the direction of Mr. F. L. Wheaton, Engineer of Construction.

Notes on the Panama Canal, Past and Present.*

By H. F. HODGES.†

The history of the attempts to establish connection between the Atlantic and Pacific oceans across the American Isthmus is very interesting, and dates back to the time of the first crossing by Balboa from Caledonia Bay to San Miguel Bay in 1513.

Early History.

The first commercial route was that laid out from Old Panama to Nombre de Dios, crossing the Chagres River at Cruces, which lies about two miles above the point at which the line of the present projected canal leaves the river valley. The Atlantic terminus of this road was moved from Nombre de Dios to Porto Bello, when the latter place became the important seaport on the Caribbean Sea, and it was used for many years for the carrying of merchandise and silver from the warehouses at Old Panama for shipment in the galleons waiting at Porto Bello. It was this road which was followed by Morgan's men in their raid which resulted in the destruction of Old Panama in 1671, two years after the same bloody leader had sacked the seaport of Porto Bello. The road is still in existence, and although the greater part of it is swallowed up in the jungle, many miles of it may still be followed, and in parts the pavement is to-day in almost perfect condition.

Beside the crossing thus established on the Isthmus of Panama other routes were followed, particularly the one at Tehuantepec, but the establishment of all these land routes was incident to the search at first for a natural avenue of water transportation and later for the most practicable route by which an artificial waterway might be established. This search was prosecuted by Spain with vigor in the early part of the 16th century, but later was laid aside and not actively resumed by the mother-country until shortly before the loss of her Central American provinces, which caused her to abandon it altogether.

The project, however, was one in which the entire civilized world was interested, and other nations undertook investigations looking toward carrying it into effect.

CANAL ROUTES.—No less than 19 different routes have received consideration and more or less careful examination. Of these the Tehuantepec, Nicaraguan, Panama and Darien lines are the four principal ones, and among them those by way of Lake Nicaragua and of Panama have been most prominently before the public in recent years. Both have had their advocates, and companies have been formed and concessions granted for the prosecution of both enterprises.

The first commercial fruit of these concessions was the existing Panama Railroad, based upon a grant by the Government of New Grenada made originally to a French company in 1838, and covering roads, railways, or canals. After very inaccurate preliminary investigations and reports the French Government took up the matter, and sent an engineer named Napoleon Garella, who in 1844 made an accurate report, recommending the construction of a canal.

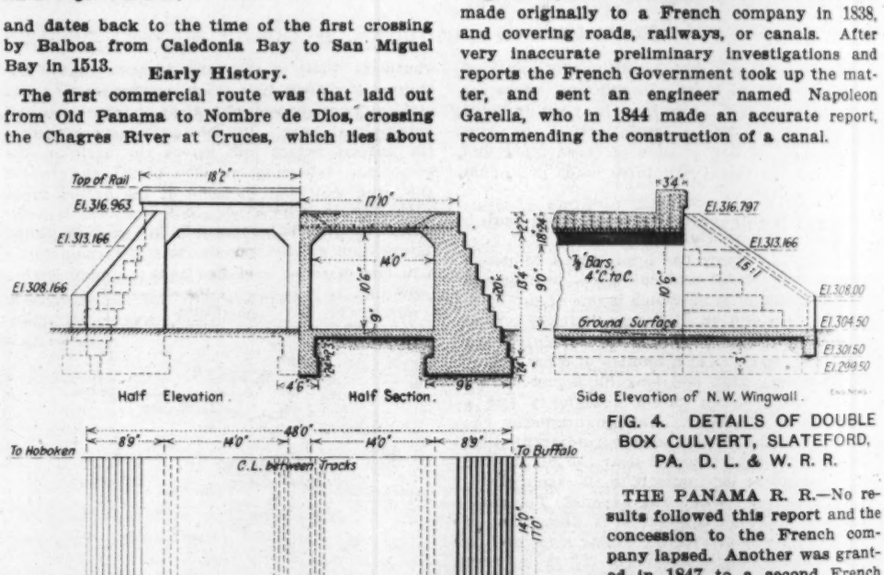


FIG. 4. DETAILS OF DOUBLE BOX CULVERT, SLATEFORD, PA. D. L. & W. R. R.

THE PANAMA R. R.—No results followed this report and the concession to the French company lapsed. Another was granted in 1847 to a second French company, but was later withdrawn, and subsequently, in December, 1848, was granted to Messrs. Aspinwall, Stephens, and Chauncey, representing an American organization. Through their efforts the Panama Railroad Co. constructed its road from Aspinwall (now Colon) to Panama between 1850 and 1855, and by a subsequent modification of the original charter the company acquired exclusive rights within a certain territory for a period of 99 years, beginning in 1867.

After the Civil War the United States Government renewed its efforts looking toward the establishment of maritime communication across the Isthmus. The line was surveyed in 1875 from

*Abstracted from a paper read before the Engineers' Society of Pennsylvania at Harrisburg, Pa., June 10, 1909.
†Lieut.-Colonel, Corps of Engineers, U. S. Army; Member of the Isthmian Canal Commission.

Limon Bay to the Pacific terminus south of Panama, and this line has been followed substantially in subsequent projects.

THE FIRST FRENCH WORK.—In 1876, before the United States took further measures, a French association obtained exclusive concessions from the Colombian Government covering the entire territory of the Republic, contingent, however, upon its quieting any claim which

FIG. 5. VIEW OF THE SLATEFORD CULVERT, D. L. & W. R. R.

should arise, due to the infringement of the existing rights of the Panama R. R. Co. The Association then convoked a Congress, known as "The International Congress of Surveys for an Interoceanic Canal," which met in Paris in May, 1879. The action of this Congress appears to have been swayed by the influence of M. de Lesseps, and it pronounced in favor of the sea-level canal from the Bay of Limon to Panama Bay, estimating the cost at about $240,000,000, including interest; and the time of completion at 12 years. It is interesting to note, in this connection, that out of the 135 members of the Congress only 98 were present when the sea-level resolution was passed, and only 78 voted in favor of it, and it is stated that the majority of the engineers and contractors present at the Congress were opposed to the resolution.

Immediately after the Congress the Universal Interoceanic Canal Co. was formed, with M. de Lesseps at its head. This company purchased a controlling interest in the Panama R. R., thereby insuring itself against any claims from that source, and entered upon the work of constructing the canal. It was at first the intention to let the entire construction as one contract, but after preliminary measures had been taken, objections which were deemed controlling were found, and the work was subdivided into several smaller contracts.

In the meanwhile the estimates of the Congress had been modified, reducing the cost and time. Until 1887 the work proceeded along the sea-level plan, it being intended to exclude the Chagres River from the canal by a dam at Gamboa, and to carry its waters and that of the other rivers to the sea through diversion channels to be opened on either side of the canal and approximately parallel to it.

In 1887 the financial difficulties of the company, and the evident impossibility of completing the work with the funds available, or within the estimate, led to the substitution for the sea-level plan of a plan involving a temporary lock canal. The surface of the summit level of this canal was to be about 160 ft. above sea-level. The construction of the locks was provided for by contract, and the excavations for these locks may still be seen at certain points of the existing canal prism.

Failure of the company to place its bonds, even after this change of plan, resulted in its downfall, and in February, 1889, it passed into the hands of a receiver.

The company expended in various ways about $200,000,000, and accomplished about 73,000,000 cu. yds. of excavation.

THE NEW FRENCH COMPANY.—The New Panama Canal Co. was formed in October, 1898, and resumed operations on the canal, principally in the Culebra cut. This company continued its work until the enterprise was finally taken over by the United States Government. It accomplished about 10,000,000 cu. yds. of excavation, principally in the Culebra cut, and the investigations which it undertook of all questions bearing upon the construction of the canal were very thorough and of great value.

The plan which the company followed contemplated a lock canal with two levels above the sea—one of them an artificial lake to be created by a dam at Bohio and reached from the Atlantic side by a flight of two locks. Above this was the summit level, with its bottom 68 ft. and its surface 102.5 ft. above sea-level, and with a bottom width of about 98 ft. This summit level was to be supplied with water through a feeder reaching from a reservoir made by a dam at Alhajuela on the upper Chagres River. On the Pacific side were also four locks at Paraiso, Pedro Miguel, and Miraflores, the two middle locks being combined in one flight. The locks were to have twin chambers, each with usable dimensions of 738 ft. in length and 82 ft. in width.

In addition to this plan the engineers also had another one in view in which the upper level was omitted, and the cut through the ridge was correspondingly deeper. The dam at Bohio was retained, and the Chagres was allowed to flow directly into the lake, which became the summit level. Between Bohio and the sea the canal was to be paralleled by diversion channels, the reservoir above the Alhajuela Dam and Lake Bohio were counted upon to retain a portion of the flood of the river, and a system of sluices and regulating works was devised to keep the portion admitted into the diversion channels below Bohio within the capacity of these channels.

The first few years' work on both these projects would have been useful on either, and it was the intention of the New French Canal Co. to make use of the second low-level plan in case its experience should indicate such a course as wise.

AMERICAN NEGOTIATIONS.—On March 3, 1899, the Congress of the United States passed an act empowering the President to make full and complete investigations of the Isthmus of Panama, with the view to the construction of a canal. He was authorized to investigate any and all practicable routes, and especially the Nicaraguan and Panama routes. Under authority of this act an Isthmian Canal Commission was appointed by the President, which reported in November, 1901, in favor of the Nicaraguan route, having in view the fact that the existing New Panama Canal Co. demanded for its rights and property the sum of $109,000,000, which sum made the estimated cost of the canal by the Panama route exceed that by the Nicaraguan route. After subsequent negotiations with the New Panama Canal Co., which resulted in the withdrawal of its previous demands, and an offer to transfer its rights and property to the United States Government for $40,000,000, the Commission, in January, 1902, submitted a supplemental report in which it favored the Panama route. Congress then, in June, 1902, passed an act empowering the President to proceed with the construction of the canal by the Panama route in case the rights of the New Panama Canal Co. could be purchased for $40,000,000, and suitable arrangements could be effected with the Republic of Colombia regarding the control of the necessary strip of land; and in the event of failure of either of these negotiations, to adopt the Nicaraguan route.

PURCHASE BY THE UNITED STATES.—Under this law the rights of the New Panama Canal Co. were acquired for the sum of $40,000,000, the sum of $10,000,000 was paid to the Republic of Panama, the successor of the Colombian Government in this region (both of these acts being accepted in subsequent legislation), and the construction of the canal has since been in progress.

There is no doubt that the United States Government received full value for the $40,000,000 paid to the New French Canal Co. In return for this amount it acquired about 30,000 acres of land, which, with the land belonging to the Panama R. R. Co., constituted a great part of what had to be acquired for the construction of the canal, the remainder being purchased later from private holders for less than $300,000. It also acquired all the buildings, plant, and other property belonging to the company, the work done by that company, which amounted to nearly 40,000,000 cu. yds. of usable excavation, and practically all of the shares of the Panama R. R. Co.

The excavation alone was worth nearly the whole sum paid by the company. The plant has also proved of considerable value, and much of it has been restored and used. We have had as many as 200 of the French locomotives in service, 700 or 800 of their dump cars, and we have built seven ladder dredges out of fragments of others, these dredges alone being worth, in the aggregate, at least $500,000 to the Commission. The railroad also is not only a valuable property, worth several million, but is indispensable in the canal work.

The American Canal.

INTERNATIONAL CONSULTING BOARD.—The type of the canal to be adopted was decided by Congress in accordance with the minority report of a Board of Consulting Engineers appointed in 1905 by the President from men distinguished in their profession in all parts of the world. This Board consisted of five members from European countries and seven Americans; of these five foreigners and two Americans were in favor of a sea-level canal, while five Americans, citizens of the country which will have to foot the bills, were in favor of the lock type of canal.

THE MAJORITY'S SEA-LEVEL CANAL.—The sea-level canal recommended by the majority of the Board was to be 150 ft. wide at the bottom in earth cutting and 200 ft. wide in rock cutting. It was to follow a line consisting practically of a series of curves, and was to have a tide lock at the Panama end.

It must be remembered that the tidal oscillation on the Pacific Coast reaches an extreme of 20 ft. from high water to low water, while that on the Atlantic Coast is only 2 ft. Even in a sea-level canal, therefore, a tidal lock is a necessity.

The old enemy of the canal, the Chagres River, was to be cared for by the construction of a large dam at Gamboa forming a reservoir. Regulating devices were proposed by which the waters of the Chagres were to be admitted to the canal at a maximum rate of 15,000 cu. ft. per sec., greater flood discharges being temporarily absorbed by the reservoir. Even this assumed maximum was calculated to produce a current of 2.6 ft. per sec. in the canal.

The main tributaries from the west were to be cut off by minor dams, of which four were to be built, and carried to the sea by diversion channels; while certain of the smaller tributaries were to be taken into the canal directly.

The time of construction was estimated at 12 or 13 years, by the Consulting Board, and at 18 to 20 years by the Canal Commission.

In its consideration, which resulted in the recommendation of the sea-level type, the majority of the Board of Consulting Engineers compared its plan with a lock canal involving a summit level of 60 ft. above sea-level, and two locks on either slope, those on the Atlantic side to be placed at Gatun and Bohio, and those on the Pacific slope at Miraflores.

THE MINORITY'S 85-FT. LOCK CANAL.—The minority of the Consulting Board, consisting of the five American engineers to whom reference has already been made, favored the adoption of the lock canal with summit level of 85 ft. above mean tide. This summit level was to be maintained by a great dam at Gatun, and a smaller dam at Pedro Miguel, making a lake 164 square miles in area. From this level vessels were to be passed at Gatun to the sea-level by a flight of three locks, and at Pedro Miguel to a lake 30 ft. lower, formed by a dam at La Boca. Through the last-named dam the sea-level of the Pacific Ocean was to be reached by means of a flight of two locks. The prism of the canal was to be 200 ft. wide in the Culebra cut and for the remainder of the distance 300 to 1,000 ft. wide. The least depth was to be the same as that adopted in the sea-level plan—namely, 40 ft.—and the locks as originally recommended were to be 900 ft. long and 95 ft. wide. The estimated cost of this canal was about $140,000,000, or more than $100,000,000 less than that of the sea-level canal, and the estimated time of completion was nine years.

THE LOCK CANAL ADOPTED.—The plan favored in the minority report was also favored by the majority of the then existing Isthmian Canal Commission, all but one member supporting it. It was also strongly endorsed by Mr. John F. Stevens, then Chief Engineer of the Commission. It was warmly recommended by the Secretary of War, who, however, reserved his support as to certain points, particularly the location of the locks on the Pacific slope; and it was recommended for adoption to Congress by the President. Congress adopted it by the act of June 29, 1906, which provides that "a lock canal be constructed of the general type proposed by the minority of the Board of Consulting Engineers," and under this plan, with some modifications, the work has since been proceeding at a rate which promises its completion within the estimated time of nine years from the date of the adoption of the plan.

MODIFICATIONS.—The principal ones among the modifications alluded to are the removal of the dam and flight of two locks on the Pacific from La Boca to Miraflores, the widening of the Culebra cut from 200 to 300 ft., and the increase in the size of the locks to 1,000 ft. long and 110 ft. wide.

Main Features of the Problem.

A few words may not be out of place here on the main points which should be considered in comparing the relative merits of the sea-level and lock types of canal as proposed by the Consulting Board and now in process of construction.

The natural divide between the two oceans on the route followed by the sea-level was 333 ft. high above mean tide on the center line when first attacked by the French, and more than 500 ft. high where cut by the eastern side slope.

By either type of canal, the distance from shore to shore is about 42 miles. Through this distance the sea-level project presents a narrow channel, with curves such that for 19 miles a vessel would have to proceed with much caution and whenever it should meet another vessel one or the other would have to stop and tie up. For the corresponding distance in the lock canal the courses are reasonably long and straight, giving a clear view ahead. The bottom width will permit vessels to pass without tying up. For the first 15 miles from the dam at Gatun through the lake the width is 1,000 ft.; for the next four miles the vessels must proceed through a channel 800 ft. wide, and for four miles further on through a channel 500 ft. wide. For the full distance of 23 miles from Gatun to Bas Obispo the shores of the lake are distant from the channel and there need be practically no speed limit enforced. Even through the deep cut from Bas Obispo to the lock at Pedro Miguel the width of 300 ft. will permit of easier navigation than the width of 200 ft. adopted for the sea-level canal. In such a channel there is no difficulty in vessels passing each other.

One can readily see that the amount of excavation in even the narrow canal projected by the majority of the Board is vastly in excess of that involved in the 85-ft. level project. Nevertheless, the great problem of the sea-level canal is not that of removing this material, but rather that of controlling the Chagres River. The attempt was made by the first French Canal Co., and was necessarily abandoned after vast sums had been sunk. It requires great dams, reservoirs and diversion ditches, the magnitude of these subsidiary constructions being hardly less than that of the main canal prism.

On the other hand, the lock canal converts the Chagres from a formidable enemy of the project to its main support and friend by creating an artificial lake in the valley of the river, which serves as a reservoir of sufficient capacity to absorb the floods without injurious effect, and to store them until the failure of the rain during the dry season shall make it necessary to draw upon the reserve thus formed for lockage purposes.

The dam forces the water of the reservoir so far up the valley of the upper river that the shock of the floods will not be felt in the lake itself. At the same time the broad channel in the lake, unrestricted by the rocky banks of the sea-level cut, affords to navigation far better facilities for speed and safety.

Much has been made by the upholders of the sea-level plan of the dangers supposed to exist for vessels in passing the locks of the adopted type.

The opponents to the lock canal point out as one of the great objections to this type the danger that vessels may carry away the gates of the lock, and thereby effect a connection between the upper and lower levels, stating that, in such event, the whole of Gatun Lake might be emptied and navigation be suspended for an indefinite period, apart from the loss of property and life which might ensue. As an answer to this we may point to the result of experience. At Sault Ste. Marie the gates, which are unprotected, have been struck several times. On the American side the result has never been anything more than a relatively trivial damage either to the ship or to the work. On the Canadian side, the result of the last accident [June 9, 1909; see Eng. News of June 17, 1909, et. seq.—Ed.] was to establish connection in the lock between the two levels. [The prompt repair of the damage at the Canadian lock was reported in Eng. News, June 24, 1909.—Ed.] This is the result from which the opponents of the lock type predict most dire disaster, even extending so far as the obliteration of the Isthmus of Panama. It thus appears that in a case where this dreaded accident has happened the consequences are not nearly so formidable as had been predicted.

On the Manchester Canal, Mr. Hunter, the Chief Engineer, points out several accidents in which the gates have been struck and even carried away by passing vessels, but in none of these does the result seem to have been so serious as the advocates of the sea-level plan contend; nor do any appear to be such as cannot be guarded against with suitable precautions in the plan and operation of the system.

The engineers who are now engaged upon the actual construction of the canal are content to attend to their work and say little, and for this reason, perhaps, most of the letters with which the public press has recently been flooded, have come from those who, for one cause or another, are opposed to the execution of the plan which Congress has ordered. Perhaps this is the reason why we have seen no reference to the dangers to navigation inherent in the passage of a narrow canal of practically one continuous series of curved lines, and for the most part with rock walls, even though that canal be without locks and at a uniform level. The sinking of a steel-hulled vessel in such a channel might mean a long suspension of navigation, and certainly does mean considerable delay.

Without endeavoring to give any general statistics as to such accidents, we may take again as an illustration, navigation in the St. Mary's River, which is a combination of lock navigation when passing the falls, and open river navigation below. Before the present broad and convenient channels were made in the Hay Lake and the Neebish, vessels had to use the channel of the main river, which had been improved, but was still inconvenient for navigation, the condition approximating to that of a narrow sea-level canal, with many curves, similar to that which has been taken in comparison with the present adopted lock type at Panama.

The most serious delay at the American Canal at Sault Ste. Marie, due to accident at the locks, was the one alluded to above, in which one of the emptying valves broke and navigation was delayed for three days, the total time lost to vessels was 448 ship-days, and the estimated cost to navigation was $56,000. A year later, the sinking of a single vessel in the open river at St. George's Flats, 21 miles below the lock, practically blocked navigation until a channel could be dredged around the sunken wreck, it being manifestly impossible to remove the latter within a reasonable time. The total delay in days elapsed was about twice that in the case of the lock accident. Reckoning in days' delay, it amounted to 827 ship-days. The monetary loss to the delayed vessels was $146,000.

The result of such an accident in the narrow rocky cut of a sea-level Panama Canal, where dredging around an obstacle could not be readily resorted to, would unquestionably be very serious.

Simjlarly, the open channel of the St. Clair Flats Canal, although 300 ft. wide, has not infrequently been seriously threatened and once almost stopped, all but 70 ft. of the width having been blocked in the fall of 1903 by the sinking of a steamer, laden with iron ore. Vessels had to be towed carefully through the narrow open space, and no draft in excess of 16 ft. was permitted. Fortunately the season of closed navigation was near at hand, and by May of the next spring the obstacle was removed. The delay and inconvenience to navigation, however, was very great, and in a narrower channel a total stoppage for a considerable time would have been inevitable. Experience of many years with the enormous commerce of the Upper Lakes has thus indicated that the narrow curved channel, though open, is a greater menace than the lock, as such.

In short, while we may admit that the passage of the locks requires care, yet I think it a fair statement that the danger and loss of time in passing such a lock canal as has been ordered by Congress is much less than the corresponding inconveniences attaching to the passage of a sea-level canal such as was advocated by the majority of the Board of Consulting Engineers, or indeed any sea-level canal which can be built for any sum not greater than twice the cost of the lock canal.

It must be remembered that any such sea-level canal must have one lock and will, therefore, not be entirely free from any inconvenience attributable to such a structure.

Cost and Time of Construction.

COST OF THE CANAL.—A word now as to the cost of the two types of canal. The Board of Consulting Engineers estimated the cost of the lock type of canal which it proposed at $139,705,000, and of the sea-level canal at $247,021,000, excluding the purchase price and the interest on the investment, and the cost of sanitation and civil government.

Since the time of making these estimates complete information as to the cost of doing work on the Isthmus has been gained by experience, and we now know that the cost of even such canals as the Board of Consulting Engineers projected would be much greater than they then thought probable.

In addition to this, the canal now undergoing construction differs in some particulars from that on which the minority of the Board based its estimate. This is especially the case in the locks, which have been increased to 110 ft. in width and 1,000 ft. in usable length; also the narrow part of the Culebra cut has been increased from 200 ft. to 300 ft. in width.

The construction cost of the adopted project when finished will be, as now estimated, $297,766,000. If to this amount be added the cost of sanitation and civil government until the end of the work, and the $50,000,000 originally paid to the French Canal Co. and the Republic of Panama, the total cost, excluding interest, to the United States, of the lock type of canal now under construction, will be $375,201,000. Experience enables this estimate to be made with a reasonable degree of certainty.

Guided by the same experience, the cost of the sea-level canal of the type recommended by the majority of the Board of Consulting Engineers would be, for construction alone, $477,601,000, and the total cost, including sanitation, civil government, and the purchase price, would be $563,000,000. These estimates, however, contain more unknown factors than those for the lock canal, such as the work at Gamboa, both in the dam itself and in the diversion of the waters of the river to permit of the construction of the dam. It should be remembered also that the estimate for the sea-level canal is for a narrow 150 and 200-ft. channel, and that the cost of a wider and straighter channel would be very greatly increased.

TIME OF COMPLETION.—In the point of time of completion, the balance is emphatically in favor of the lock type of canal. The date of completion of the present plan will be fixed by the lock and dam work, rather than by the excavation. It is now expected that the canal will be ready for use by 1915.

The time of completion of the sea-level canal would be determined either by the excavation, or by the Gamboa Dam. While the excavation in the Central Division, which contains the Culebra cut, has recently been going forward at a rate which exceeds the original hopes of the Commission, yet the maximum rate has probably been reached already. The total yardage taken out during the month of March, last, was 4,070,000 cu. yds., of which more than 2,000,000 cu. yds. were from the Central Division; but it is the general belief on the Isthmus that these figures will never again be equalled, and that from now on the yardage of the dry excavation will show no further increase, and will soon begin to diminish. This is unavoidable sooner or later, since, as the cut narrows toward the bottom, the amount of plant which can be used becomes more and more restricted. Were it required to carry the cut to the depth necessary for a sea-level canal, which would be at least 80 ft. below the bottom of the lock canal, the additional length of time would not be simply proportional to the yardage, but would increase much more rapidly than that quantity, owing to the continued contraction of the space, and the consequent decrease in the amount of plant which could be used.

There now remain about 50,000,000 cu. yds. to be taken out in the Central Division to complete that part of the excavation, for the adopted plan. For the sea-level plan that same division would still have about 220,000,000 cu. yds. Remembering that the present rate in that division of 19,000,000 cu. yds. per annum must diminish greatly in the lower levels, and that some time must be taken to revet the walls after finishing the excavation, it is evident that the old estimates of from 13 to 20 years for completion of the sea-level canal are not far astray.

Until recently there has been no serious suggestion that the sea-level plan would not take much longer to complete than the lock canal, and even now those who make such a suggestion base their views upon the continuation, and even the increase of the most favorable rate of excavation yet attained, and upon the use of devices not yet sanctioned by experience.

Even leaving out of consideration the unknown factor of the Gamboa Dam, and basing the estimate upon the excavation alone, it would evidently not be safe to believe that even the narrow sea-level canal, such as was contemplated by the majority of the Board of Consulting Engineers, would not take at least six years longer to finish than the lock canal, and were a broader and more convenient channel to be attempted a further increase in the time would result.

[Here Col. Hodges describes the Gatun dam, whose design and the controversies about it have already been fully presented to our readers. We retain only the paragraphs referring to the wasteway provisions and the relation of floods to Gatun Lake, and those which tell of the present state of the construction.—Ed.]

FLOOD DISPOSAL.—One of the features of the Gatun Dam which must not be overlooked is the means for carrying away the discharge of the Chagres River when the latter is in flood.

The great reservoir formed by the lake is capable of absorbing a large part of the ordinary discharge of the river during the wet season and storing it for use in lockage during the dry season. The variation in the level of the lake available for this purpose is about 80 ft., that is from Reference 82 to 87. Above Reference 87 it is not designed to allow the water of the lake to rise, the reference of the lock walls being 92, or 5 ft. above the highest lake level. To prevent its rising an escape weir is provided, located in a natural hill where the rock comes close to the surface. A channel has been excavated through the rock, and it is designed to construct across this channel a concrete dam, with its crest 16 ft. below the normal lake level of 85 ft., and having at its top lifting gates of the Stoney type, which, when lowered, form effective dams against the water, and when raised permit the water to flow out under the lower edge of the gates and over the crest of the dam. An area will be provided to discharge a total flow of 140,000 cu. ft. per sec. over the crest of the spillway dam, and lower-level sluices will also be provided to regulate the level of the lake before it reaches the crest of the dam.

As the maximum known discharge of the Chagres is less than the amount which can pass the spillway, all danger of flooding the locks through sudden rises of the river is done away with.

It may be stated, also, that there has never been any flood in the Chagres River which would have a sudden effect on the enormous reservoir provided by the lake with its area of 164 square miles. It would take 48 hours, even with an extreme flood, to affect this level by 4 ft., even were there no water escaping through the spillway during that time.

The channel excavated for the spillway is already being lined with concrete at a low level, and it is intended at the close of the next dry season to dam off the present outlet of the Chagres River and force its waters through the spillway, while the dam is under construction.

When the earth dam nears completion the spillway dam will be hurried forward during some favorable dry season.

There will be no danger incident to this construction even were no low-level sluices provided, since it will take months for the water to accumulate in the lake, and the concrete work can readily be kept ahead of the slowly rising surface. To provide, however, against any unforeseen delay, low-level culverts will be constructed in the dam, and with these and the lock culverts the lake level can be drawn down at any time, if desired.

PRESENT STATE OF WORK.—It was the opinion of the old Isthmian Canal Commission, and it is the opinion of the present one, that the lock canal which has been ordered by Congress is superior to the sea-level plan, giving due weight to all the elements of suitability, cost, and time of completion. The work on this plan has now reached such a stage that to revert to the sea-level canal would mean a waste of many millions of dollars. Within six months this sum will have greatly increased. Opposition to the type of canal ordered by Congress, with whatever motive it may be urged, is in practical effect opposition to the construction of any canal at all, for, in view of the enormously increased expenditure necessary for a convenient sea-level canal, the abandonment of the lock canal project would undoubtedly mean the abandonment of the canal altogether.

The Gatun Dam, which has just been described, occasions a difference in level between the navigable waters above and below, amounting to 85 ft. at normal lake level. At this level the lake covers an area of 164 square miles. This difference in level is overcome by a flight of three locks. These locks are to be of concrete, reinforced only in a few places, and dependent in general upon their mass for stability.

The excavation for the upper lock is practically complete, and within a few weeks the operation of concrete placing and mixing will begin. On the western slope the work has progressed to about the same extent as it has on the eastern slope. The excavation for the lock at Pedro Miguel is practically finished and concrete laying will begin there within the next few weeks. The construction of the dams there and at Miraflores has made reasonable progress, and the excavation for the locks at Miraflores is as far under way as it is desirable to have it now. On this slope the work will begin first at Pedro Miguel and, to avoid duplication of plant, the Miraflores work will follow in due course after that at Pedro Miguel.

As Pedro Miguel is one terminus of the Gatun Lake, there is no necessity for a spillway at this point since the lake level is regulated by the large spillway works at Gatun. At Miraflores, however, a spillway is necessary to control the level in the Miraflores Lake and especially to avoid trouble in case for any reason there should be a rush of water from the upper level through the Pedro Miguel locks and into the lake below. A spillway is, therefore, proposed for the Miraflores Dam, with capacity sufficient to discharge any possible outflow from the upper level, above Pedro Miguel Lock. The flood discharge of the tributaries of Miraflores Lake is insignificant and could be cared for with little difficulty.

The plans for the upper chamber at Gatun are complete, as well as for the single lift at Pedro Miguel on the Pacific slope, and advertisements for the fixed iron work and subsidiary valves have already been made public. It is of interest to note that while these items are only for the subsidiary valves and the ordinarily insignificant parts which go into the anchorage and sills for the gates, yet the total consideration of the contract will probably amount to about $700,000.

[We omit here Col. Hodges' description of the locks and lock gates, these having been described in our issues of July 15 and Sept. 16, 1909. The following paragraphs on the water supply, and the locking capacity of the canal as dependent thereon, are of much interest, since they summarize the results of long-continued observations of the water problem at Panama.—Ed.]

The Water Supply: Lockage Capacity.

Question has been raised in regard to the adequacy of the water supply to maintain a large commerce through the locks. This point has

been under investigation for many years, and data bearing upon it have been collected and studied with the greatest care.

It is known that during eight or nine months of the year plentiful rainfall is available, whereas during the remaining four or three months there is practically none, and it becomes, therefore, a question of storing during the rainy season a sufficient supply to last during the dry season. The enormous reservoir capacity of Gatun Lake is available for this purpose. With the bottom of the canal excavation in the summit level placed as it is at 40 ft. above the sea-level, it is evident that navigation, with the extreme depth desired, of 40 ft. in salt water, can be carried on until the surface of the lake falls to the Reference + 81⅔. As it is intended to allow the water to rise up to Reference + 87, there is a little more than 5 ft. of storage available. With this amount of storage, and making due allowance for power consumption, evaporation, seepage and leakage at the gates, we find that during a dry season of minimum recorded flow, assumed to coincide with the wet season of minimum flow, an average of 41 passages of the canal per day would be possible, and that in the average dry season the daily number of 58 double lockages is possible; that is, 58 complete transits of the canal. Such a number is more than the 24 hours of the day would permit, allowing vessels to follow each other at intervals of one hour, and we may safely say that the water supply is considerably in excess of any demands which can be made upon it. The limit is, of course, only imposed for the dry months. During the rainy months there is practically no limit except that of time.

With the design adopted for the locks a certain amount of water can be saved at each lockage at Gatun or Miraflores whenever a vessel does not draw the full permissible depth of 40 ft., as will be the case in 90 lockages out of 100. This saving can be effected by cross filling, or emptying through the middle wall into the other twin lock chamber.

On the whole, it is safe to count upon water for as many lockages as the time in the day will permit.

The traffic of the Suez Canal now amounts to about 21,000,000 gross tons per year, carried by about 12 passages per day. The commerce of the American Canal at Sault Ste. Marie, which, with its two locks side by side, offers the same facilities as do the twin locks of the Panama Canal, amounts to say, 40,000,000 tons of freight annually and is carried on an average of about 35 lockages per day during the season of navigation, or 24 lockages per day during the calendar year.

It is often assumed that the construction of the lock canal limits navigation forever to the facilities provided by that canal as originally constructed. This is not at all the case. Other locks can be built paralleling those now to be built and tributary to the same trunk canal, as has been done at Sault Ste. Marie, and a dam may be built at Alhajuela to provide additional water supply for these new locks.

The situation is then this: the canal which is now proposed, with its type of locks devised to economize water will provide, as shown, for as many lockages as the 24 hours of the day will permit, namely, 48 complete passages of the Isthmus daily. Such a number of lockages on the basis of carriage now in existence at St. Mary's River, will accommodate 80,000,000 tons per annum. A commerce of this magnitude is many, many years in the future, and, if we give present facilities for it, it will only be in the time of our far distant posterity that these facilities will need increase. We may safely leave to that posterity the chance to spend some of its own money in meeting the need, should it ever arise.

EARTHQUAKES AND WAR.—There has been some allusion in the public print to the danger from earthquakes in the Canal Zone. I am unable to promise that they will not occur, but we have very direct and striking evidence that none has occurred with any degree of severity for the last 200 years. There are ruins of that age now standing in New Panama, as well as in Old Panama, which would unquestionably have fallen under a shock of any magnitude.

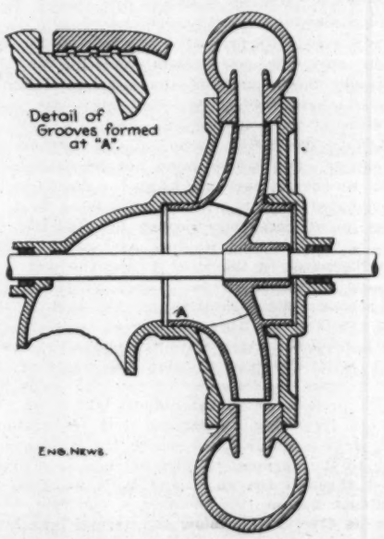
If we are to have a canal of any practicable description across the Isthmus we must take the chance of earthquakes, for they might destroy the dams and tidal lock of a sea-level canal, as well as the structures belonging to the approved type. It may be stated that it would take a considerable jar to affect injuriously any of these structures.

We do not need to discuss at length the vulnerability of the lock canal in time of war, although its alleged weakness has been urged as an objection. Any canal that we can build there will be vulnerable, and if we are to hold it we must defend it, and not trust to its type for its protection.

Loss of Efficiency of Centrifugal Pumps Through Vibration.

By A. P. BLACKSTEAD.*

Among the several causes of the decreased efficiency of a centrifugal pump, there is one that usually fails to receive deserved attention. This is the loss brought about by vibration, and it becomes most serious with high-speed, high-lift pumps, where clearances around the impeller are reduced to a minimum. The impeller is allowed to rub against the casing fittings with a



Sketch Showing Grooving of Centrifugal-Pump Casing, Caused by Vibration.

true brake action. These vibrations may be caused by too light foundations, by a loss of alinement of rotor bearings, by a shaft sprung out of true shape, by a mechanically unbalanced rotor or by a rotor with lack of hydraulic balance. Occurrence of all but the last named cause are self-evident. Hydraulic unbalance occurs when the impeller periphery has not uniform width of opening or when the impeller vanes are not all placed at the same angle.

A case has recently been brought to the writer's attention, where a centrifugal pump had its efficiency reduced some 7% on account of vibration. This pump was a medium-sized, high-head, horizontal type and was erected at first on a temporary foundation which permitted heavy vibration. After a few hours run the pump was taken apart and the conditions shown in the accompanying sketch were found.

Grooves 1/32 in. deep were formed in the side plates and these grooves were of the same width as the male projections between the water-labyrinth grooves on the impeller. As they were of the same depth on the top, sides and bottom of the side plates it was evident that they were not due to a displacement of the shaft centers. The shaft was not sprung as the impeller could be freely revolved by hand.

Before removing the pump from the temporary foundations a careful test was made to determine the pump efficiency. The pump was later reassembled and placed on heavier foundations which gave a smooth running machine with no vibrations. The pump was next given a series of tests under the old conditions of head, speed, etc., and it was found that the efficiency was 7% greater than before.

*Camden Iron Works, Camden, N. J.

The Progress of Movements Toward Municipal Charter Reforms.

By CLINTON ROGERS WOODRUFF.*

BOSTON.—The graphic illustrations and maps of the Bureau of Municipal Research in New York city did almost as much to arouse public interest and shape sentiment there on the necessity of budgetary reform as did their compact presentation of figures. Diagrams are being found of increasing value in formulating and illustrating arguments on matters of public organization. These methods are being pursued in Boston in the pending charter campaign.† Harvey S. Chase, a well known public accountant of that city and an active worker for municipal improvement in the National Municipal League, has graphically depicted the plan urged by the politicians locally, known as "Plan No. 1" (see accompanying figures), and the one urged by the Finance Commission and public spirited citizens cooperating with the Committee of One Hundred for its adoption. The diagram shows how, under the former, the city electorate is broken into two unequal parts, the ward electorate and the municipal electorate, with the election of the councillors divided between them. Plan II. is shown to be a governmental unit starting directly from the people, irrespective of party affiliations. Any petition signed by 5,000 voters may nominate a candidate for mayor, councilman or school director. That is all there is to the whole plan, and there are only 15 elective officers all told, no more than six of whom, three councilmen, two school committeemen and one mayor, can possibly be elected at one election. In other words, it introduces the short ballot, whereas Plan I. provides for undivided responsibility and an unwieldy body of legislators. Complexity characterizes the one; comparative simplicity and directness the other. So much for the situation in Boston.

ST. LOUIS.—Here a Home-Rule Board of Freeholders is at work and the same fight for simplicity is being made, but with what result it is impossible to foretell. The St. Louis Civic League, an unusually effective organization, has very carefully studied the situation and made suggestions under the title of a "Plan for New City Charter" that is worthy of thoughtful consideration. This plan seems to be an attempt to graft the best ideas of the English and Prussian systems oh the American federal system. It suggests that the municipal assembly should be composed of 18 members, receiving each an annual salary of $2,400, and elected at large for terms of six years; six of these members would be elected every two years. Vacancies by death, or resignation, would be filled by the municipal assembly from the districts in which the vacancies occur. The city would be divided into three or six general districts, six or three of the members of the assembly, in either case respectively, to reside or do business in each district.

The 18 members of the assembly would be assigned by itself, two to each of the nine departments as members of a supervisory committee. The mayor would, furthermore, be charged with the duty of appointing two responsible citizens, not holding public office and selected for their special information and qualifications, to act in conjunction with the members of the assembly. These four persons so designated would have, however, only supervisory, not directory power over the department. The mayor, who would be elected for a term of four years, would be the executive officer of the city and primarily responsible for the administration, with power to appoint the heads of the city departments (ex-

*Secretary of The National Municipal League, 703 North American Bldg., Philadelphia.

[†Details of the proposed changes were published in Engineering News, July 15.—Ed.]

cept the Commissioner of Eleemosynary Institutions) and the power to remove them for any reason assigned of record. He would be Chairman of the Board of Administration and have direct charge of the police (so far as permitted by law), the municipal courts, the law department, the fire department, penal institutions and public order generally, but with no power to select the appointees under the heads of departments.

The heads of the administrative departments, nine in number, would constitute a board of administration, to which all administrative affairs would be reported, and whose action should be subject to the approval of the board. The estimates for all public expenditures would be made by this board and submitted to the municipal assembly as a basis for its appropriations. It would have the contracting power of the city, subject to the appropriations and general ordinances. All condemnation, street improvements and vacations, all establishment of sewers, and sewer districts, and all permits of all kinds, such as under the present city charter require ordinances of a limited or not general character, would be adopted by this board under such general ordinance provisions as the municipal assembly might enact. Franchises would be recommended by the Board of Administration after public hearings.

It is recommended that

> the scope of the charter should be as simple as possible and follow the lines of the present charter wherever practicable. The expression of the municipal power should be declared in general terms, rather than in detail. The charter should contemplate ordinances relating to every department to carry its provisions into practical effect.

Every publicist will be in hearty accord with such a recommendation.

CHICAGO.—Whatever Boston and St. Louis may adopt will reflect the wishes of the electors of the two communities, the former being under a referendum granted by the State Legislature, the latter being under the home-rule provisions of the Missouri Constitution. Both places are in a far better position than poor Chicago, which completely failed to secure any relief whatever at the hands of the recent legislature, although what more could be expected from a body which elected a William Lorimer to the United States Senate? The situation in Chicago seems desperate, and perhaps to justify the talk that has recently sprung up to form the "State of Chicago" in order to end charter troubles. The statement is made that the people of Illinois outside Chicago would be quite as much benefited by the establishment of the new state as would those of the city itself. It is declared that legislators from Chicago are as ignorant of the needs of the down-state section as are the lawmakers from that part of the state oblivious to the needs of Chicago. The plan, as advocated, contemplates the creation of the new state from the present counties of Cook, McHenry, Lake, Kane, Dupage and Will, which would give the "State of Chicago" a population of 2,084,750 (according to the census of 1900) and an area of 3,626 square miles. With this arrangement, the State of Illinois would have a population of 2,736,800 and an area of 53,024 square miles, and practically would be an agricultural state.

Chicago could have had some of the legislation it asked for, and desperately needs, if it had been willing to agree to a permanent limitation of its representation in the legislature. The city is not anxious to set up in the state business, but its leading papers voice the demand that there should be a recognition by the whole State of Illinois of its substantial stake in the city's welfare and legitimate development.

RECALL PROVISIONS.—The recall is being inserted in most of the new municipal charters based on the commission form of government. The new Colorado Springs charter framed under the home-rule provisions of the Colorado constitution (known as the Rush amendment and modeled on the municipal program of the National Municipal League) contains a recall provision which becomes operative in six months. The Tacoma (Washington) charter-revision movement has not only embodied the recall, but is endeavoring to legislate the present city officials out of office by providing for an election this fall of a commission of five men to handle the city's affairs, the present city officials, from Mayor Linck down, having been elected in April of last year to serve "two years and until their successors are duly elected and qualified."

Two Spokane councilmen, charged with defeating the will of the people, may have to secure endorsement at the polls from their constituents or retire from the City Council. This is in accord with the provisions of the recall amendment adopted at the last municipal election in Spokane. The petition against Councilman Funk sets forth that he is not working in the best interests of the people of his ward; that he is not carrying out his ante-election pledges, and that he is working in the interest of contractors. The charges against Councilman Lambert are that he is not carrying out the expressed wishes of the people and that his work in the City Council is not satisfactory. Naturally, these two members emphatically deny the charges contained in the petitions and say they are ready and willing to go before their constituents on their records.

Haverill, Mass., one of the few eastern cities having a commission form of government and a recall appendix to the charter, is facing an exercise of the provision. Here a socialist ex-mayor is leading a movement to obtain the signatures of 25% of the voters required to recall the officials who were elected for a two-year term, and thereby obtain a special election, presumably hoping to defeat these men should they become candidates at that election, but stating that their principal reason is to show that the people desire one-year terms instead of two. Under the charter, it is necessary that reasons be given for a recall, and they have attempted to do so, but no specific act or concrete statement has been made, but general statements of poor management. It is as yet doubtful whether or not they will succeed in obtaining the required number of signatures; but if they do, representatives of the business interest state they have no fear of that element at election time, as

> the city government is of splendid caliber and ability, and is devoting its very best energies to the work, obtaining full value for every dollar expended, and will not only receive the support which they had last fall, but the votes of a great many who were opposed to the new charter and the men who were elected under it.

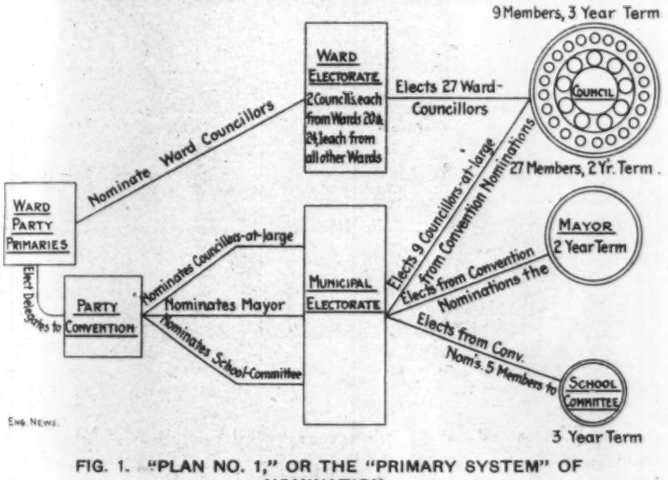


FIG. 1. "PLAN NO. 1," OR THE "PRIMARY SYSTEM" OF NOMINATION.

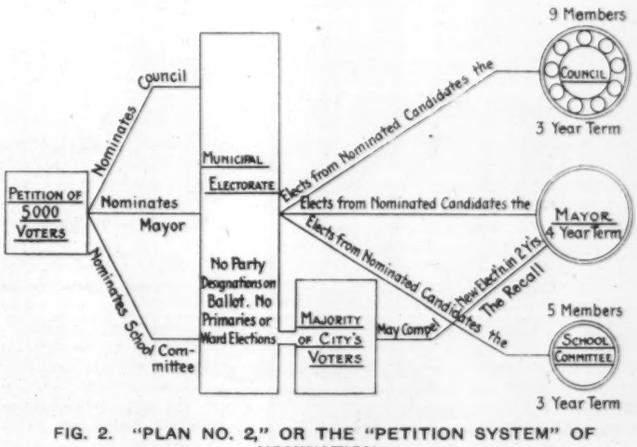


FIG. 2. "PLAN NO. 2," OR THE "PETITION SYSTEM" OF NOMINATION.

FIGS. 1 AND 2. DIAGRAMS SHOWING THE OPERATION OF THE BOSTON CITY CHARTER PLANS.
(Prepared by Harvey S. Chase & Co., Public Accountants, Boston.)

The Failure of the Bluewater Dam in New Mexico.

By GEORGE G. ANDERSON.*

The Bluewater Dam, located on a power development project in the Zuni Mountain district of New Mexico, was constructed early in the year 1908. It was of the rock-fill type, with an earthwork apron and a central puddle wall carried into the bed rock about 15 ft. below the bed of the stream. The extreme height was 55 ft. above stream bed, and extreme length 325 ft. on top. The outlet was a tunnel 4 × 6 ft. cut through the rock wall on the south side of and apart from the dam. On the same side was the spillway, on rock bed throughout. The reservoir contained at spillway level 1,200 acre-ft.; at the top of the embankment 3,200 acre-ft. The dam was built as the first stage of a structure ultimately designed to impound water to a depth of 90 ft.

With the exception of a slight leakage which occurred at the time of the first filling of the reservoir in April, 1908, on the north side of the dam, a leakage which was controlled and effectively sealed up at the time, no evidence of weakness had been manifested in the interval. The reservoir and dam had been under the constant care of a watchman, living at the site.

Commencing in the early part of July the Bluewater district had been subject to almost continuous rainfall, unusual to that section of the country. These rainstorms culminated in a prolonged storm, extending from Sept. 3 to 5, inclusive, during which time the precipitation was continuous and extremely heavy. On the morning of the 6th two "cloudbursts" succeeded one another within close intervals, over the district drained by the Bluewater Creek which, with

*Consulting Civil Engineer, 518 Equitable Bldg., Denver, Colo.

Cottonwood Creek, fed the reservoir, located at the confluence of the two streams.

About 4 p. m. of Sept. 3 (Sunday) the water in the reservoir reached the level of the spillway. At that time, there was no apparent change in the condition of the dam. The water in the reservoir rose rapidly after that time, with outlet gates open and spillway passing full and free. About 2 a. m. the watchman observed a leakage on the north side of the dam and also a slight percolation on the south side near the junction of the dam with the spillway wall. The latter subsequently ceased, apparently by choking up of a "slough" of the bank, and thereafter remained sealed. The former remained much about the quantity first developed until the final failure.

Water in the reservoir, according to the report of the watchman, continued to rise at the rate of about 0.1 ft. every 15 minutes, and was greatly accelerated by the inflow of the "cloudbursts," described as being a wall of water about 5 ft. deep on the top of the already swollen creek.

The failure of the dam occurred at 2 p. m. on Monday, the 6th inst., when the inflowing waters overtopped the embankment.

The flood of waters created comparatively limited damage, in view of the large volume. For about 10 miles below the dam, the creek follows through a close canyon, below which the valley opens up to some width. No loss of life occurred, ample warning having been telephoned from the reservoir near the dam, so that the settlers had time also to remove their household effects. No habitations were destroyed, two houses only being moved, and these to comparatively short distances. Considerable crop damage resulted, though it was confined to garden stuff largely and to the covering of alfalfa with mud. The crop of oats recovered markedly after the water passed off. The greatest injury was confined to the tracks of the Atchison, Topeka & Santa Fe R. R., which were flooded in parts for about 3½ miles. No bridges were damaged. About ½-mile of track was washed out in fill, ties and rails being moved off, and the damage for the balance of the distance was confined to the washing off of ballast.

The unprecedented floods were directly the cause of the failure.

It is understood that the Bluewater Development Co. the owners of the reservoir, are preparing to rebuild the dam as speedily as possible.

A Pressure-Regulated Electric Motor Controller.*

A type of controller has been designed by the Cutler-Hammer Manufacturing Co., of Milwaukee, Wis., for electric motors driving the blower of an induced-draft plant, of a gas-pressure booster or other similar machines where a change in pressure of air, steam or gas demands a change in motor speed. The final designs possess several points of interest which are common to all and can be shown for all on the controller adapted particularly to mechanical-draft systems.

For such a system the controller adjusts the speed of the motor, and the blower driven, to that value necessary to furnish the draft required for the boiler load. So long as the steam pressure is constant, at any point within the range of the controller, the mechanism is inactive and the motor runs at constant speed. Should the steam pressure rise or fall, this change in steam pressure so operates the controller that the motor is slowed down, or speeded up, by a proper amount to restore the desired pressure.

How this is done is shown by reference to Figs. 1 and 2. The speed of a direct-current motor is reduced below normal by inserting resistance in the armature circuits. It is raised above normal by inserting resistance in the field circuit. The diagrammatic arrangement of external circuits and of mechanical parts of a controller automatically doing these things is shown in Fig. 1, while the general appearance of the assembled apparatus is seen from Fig. 2. It should be noted that the controller shown in Fig. 2 does not regulate field current and is less complete, in that respect, than the type shown in Fig. 1. Otherwise it is the same.

The various resistance coils, or grids as the case may be, are arranged in a steel cage on the front of which is a slate panel. This carries the contact points, of the resistance units, over which the contact bar, or lever, is moved by the regulating piston to insert or cut out resistance. The contact bar is worked forward or back by the piston of a hydraulic cylinder. The admission and exhaust valves, at each end of this cylinder are actuated by the movement of a diaphragm regulator, in response to changes of steam pressure. The regulator is of the familiar type in which steam pressure on one side of a diaphragm is balanced at some normal point by a weighted lever, through a bearing pin on the other side. The rise and fall of the diaphragm and lever here operates a pilot valve which admits water, under 25 lbs. pressure, to one side or the other of the hydraulic cylinder.

The movement of the contact bar over the contact segments is not a continuous process but is made to proceed, step by step, with pauses between each movement. This is done by the belt-crank connection between the floating lever, at the pilot valve, and the piston-rod head. It will be seen from Fig. 1 that any upward movement of the weighted lever results in an upward movement of the floating lever about the end of the bell crank as a fulcrum. As soon as the lever begins to move, however, it moves the floating lever about its other end as a fulcrum and in a direction opposite to that caused by the weighted lever. This checks the pilot valve and causes the hydraulic piston to stand still until some further motion of the weighted lever occurs.

This regulator does not serve to start the motor and an ordinary starting rheostat is required in addition. For alternating-current motors a very similar apparatus is used. For multi-phase motors, resistance is inserted into the rotor circuits, while for single-phase repulsion motors, this resistance is replaced by the leads of a series-transformer for the field coils. Or the transformer may be for the compensating coils of the latest variable-speed, single-phase motors. The starting rheostat of direct-current apparatus is replaced by a solenoid-operated switch on the supply leads, mechanically interconnected with the regulator levers to prevent starting the motor unless all starting resistances are in circuit.

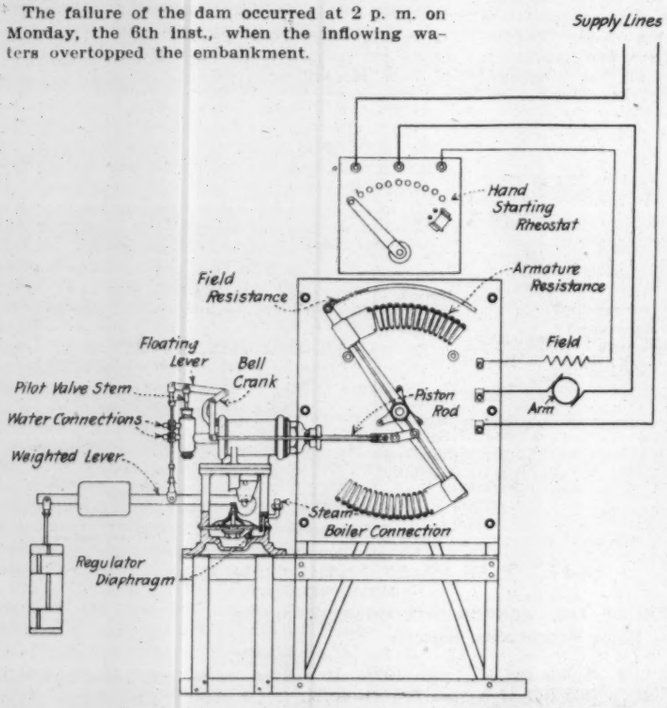


FIG. 1. DIAGRAMMATIC ARRANGEMENT OF A CUTLER-HAMMER AUTOMATIC PRESSURE-REGULATED MOTOR CONTROLLER.

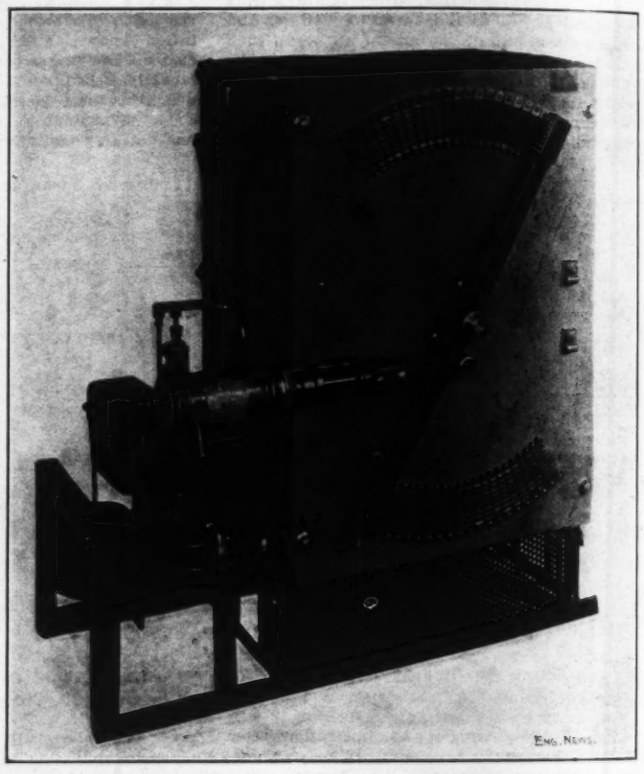


FIG. 2. AN AUTOMATIC PRESSURE-REGULATED MOTOR CONTROLLER.

*From information supplied by the Cutler-Hammer Manufacturing Co., Milwaukee, Wis.

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A satisfactory substitute for the wooden tie in railway track construction has been sought for many years, but so far the search has been practically unsuccessful, and the wooden tie holds its own, its position being strengthened meanwhile by the increasing use of preservative processes which lengthen its life. The railway companies have done little in the search for substitutes for the wooden tie, but have left the field to inventors. These have worked industriously but with little more result than to add to the long list of useless patents. The great majority of the inventions are utterly impracticable and never pass beyond the paper stage, and of the designs which secure an actual trial in railway track, only an occasional one achieves even a slight degree of success. Any substitute for the wooden tie must be practicable, durable, of reasonable cost, and have efficient rail attachments. This combination appears to constitute a very difficult problem. Steel (which has been used long and extensively in other countries, with success) is probably the favorite material of designers, and has been tried on a limited scale in a number of forms. Only one form is in use to such an extent that its use can be reckoned in miles of track; most of the others being reckoned by the dozen or the hundred. And this one design, it must be noted, is manufactured and pushed by a great steel manufacturing concern, while its most extensive use is on a railway which is owned by that concern, where the difficulties of persuading executive and purchasing officers are presumably eliminated.

Concrete has been tried in different forms, mainly with failure as the result. Much has been said of the successful use of concrete ties abroad, but certainly the results in this country have been far from promising. Yet the inventor follows the trail persistently, and new designs and new experiments are brought to our attention every little while, often with enthusiastic claims of certain success.

The present outlook for substitutes for wooden ties is well summarized in a report which is printed in another column of this issue, which presents the results of a personal investigation made by a committee of railway engineers. The results are in the main entirely discouraging, and the general indication of the report is that while further experiments are justified, there is not as yet in sight any really satisfactory substitute for the wooden tie. It is possible that greater progress might be made if the railways were to take up the matter themselves, but they have apparently little inclination to do this.

The mayor of Pittsburg has recommended the universal adoption of water meters in that city. Estimates show that to provide the additional land, filter beds, pumping station, reservoirs, etc., to supply filtered water to the former city of Allegheny, will involve a cost of about $2,500,000. The introduction of meters, on the other hand, is expected to reduce the water consumption by nearly one-third, which would make the present supply ample for the needs of the city on the north side. The cost of such universal metering is estimated at only $1,500,000. The mayor recommends the issue of bonds to the amount of $500,000 for the purchase of meters, and would provide the remaining $1,000,000 by annual appropriations.

No one familiar with the water-supply situation in American cities can doubt the need in most of them of more stringent methods to prevent waste. The experience with the meter system in cities of moderate size has amply proved its efficiency as a means of waste prevention, and also as a means of increasing the revenue from the sale of water and equitably dividing the burdens attendant upon its provision.

There is, however, one thing lacking in the meter system as at present installed. It is practically the universal practice to apply a meter only to the main service pipe as it leaves the street and enters the building. In the case of the smaller cities, where most of the buildings are occupied by individual owners or tenants, the meter acts as an effective check upon waste; but the same thing is not true in the larger cities, where a large proportion of the inhabitants live in apartments or tenements, with numerous families in a single building. Here the user of water has no direct interest in saving it. The janitor may indeed have general supervision of fixtures and may take care to stop leaks, if he looks out for the landlord's interest; but the tenants themselves have free water, and there is no inducement for them to avoid waste.

It is urged that this situation should be met by the introduction of individual meters to each apartment; but the difficulty comes in with the enormous labor which this would throw upon the water department in the collection of bills for water used. It might be said that the landlord could do this, but few owners of tenements or apartment houses would be willing to undertake it.

On the other hand, this very same difficulty besets the purveyors of illuminating gas in every city in the world, and it has been admirably solved, first in Europe and later in this country, by the introduction of coin-in-the-slot meters. It is only a few years since these were first introduced, but in England they have become well-nigh universal, and their use in this country is increasing with great rapidity. With these meters there is no question of the responsibility of the tenant for his gas bills, and the bookkeeping attendant upon the enormous number of individual accounts is wholly eliminated. The collector makes his rounds at regular intervals to collect the quarters which have accumulated in the hoppers of the meters, and does not have to bother with reading meter indications and records.

We see no reason why this same system might not be applied to the distribution of water. Indeed, it would be free from the objection which has been frequently brought against the quarter-in-the-slot gas meter—that of danger to life involved when the gas-supply is cut off. It is true that a cut-off valve in the water-pipe would require more force to open and close than the valve in a gas-supply pipe; but water pressure is available to do this work, and it is surely within the ingenuity of the designers of slot machines to design a simple device, of the coin-in-the-slot order, for connection to a water meter. It is rather surprising that some of our enterprising water-meter manufacturers have not already put a coin-in-the-slot water meter on the market. Doubtless there has been no demand for such a device; but in every new venture the supply has to precede the demand. If a satisfactory quarter-in-the-slot water meter were placed on the market, we are inclined to think it would meet with prompt favor from the water purveyors of the United States. Pure potable water delivered to the consumer costs more per cubic foot than gas in many cities. There is no more reason why the consumer should object to paying for water according to the amount he uses than for gas.

A vast deal has been published concerning the general inefficiency of government work, and particularly concerning the inefficiency of work done by American cities, burdened with various degrees of municipal corruption. It is, in fact, one of the stock arguments against municipal ownership of public utilities that city work is so often done wastefully and dishonestly that the city has to pay exorbitant prices for labor and materials. This argument is based, undoubtedly, on actual experience in not a few American cities. But those who use this argument never mention the fact that conditions quite as bad not seldom prevail when public utilities are operated by private companies.

A notable example of this latter sort was furnished recently by the city of Vicksburg, Miss., which is dependent for its water supply on works owned and operated by a private company. For three days in the early part of this month—Sept. 8, 9 and 10—the city water-supply failed entirely, due to a breakdown in the pumping station. The City Council, after the city had been without water for three days, appointed a committee of local engineers and a committee of citizens to examine the pumping plant. It was found that some second-hand boilers had recently been installed at the plant, to supplement the steam-making capacity; but "defective flues," according to the engineers' report, compelled the boilers to be put out of service for repairs. In the emergency, three river steamboats were hired and moored near the pumping station, and steam from their boilers was piped to the water-works pumps. These, however, were reported to be in very bad condition, so that only one of them could be operated, and that one was badly in need of repairs. The committee reported that "the pumping plant had more the appearance of a junk bin than a power plant."

The citizens' committee, after hearing the report of the engineers, demanded that the manager of the water-works company turn the plant over to them for operation, and they installed the master mechanic of the local railway shops in charge of the pumping station, with instructions to put the plant in first-class running order.

According to a newspaper statement, a rental of $240 a day was required to secure the use of the river steamboats for furnishing steam; so that the breakdown was a serious financial disaster to the water company, as well as a source of great peril and inconvenience to the city.

It cannot be said that Vicksburg has gone through this unfortunate experience without warning as to what was impending. In June, 1905, more than four years ago, a report on fire-risk conditions in the city of Vicksburg was made by expert engineers of the National Board of Fire Underwriters. From that report we learn that this is not the first time that Vicksburg has been without a water-supply on account of the breakdown of the pumping station. The report says:

> A breakdown of one boiler, at a time when two other boilers were being repaired, caused the shutting down of the whole pumping plant from Dec. 28, 1904, to Jan. 2, 1905, the remaining boiler not being sufficient to operate the pumps.

Other quotations from the report follow:

> Two reserve low-lift pumps on the river bank, exposed to the weather, cannot be fully depended upon to furnish a continuous supply, as they have to be moved up and down the bank under great difficulties to meet varying stages of the river, which range about 58 ft. in elevation.

Steam piping leaky in places. Pumping-station building in poor condition and exposed by a machine shop and filter-house 16 ft. distant. Two barrels of oil in storage-house carelessly kept.

Gate-valves are not inspected regularly, nor are any records kept of inspections or repairs. There has been only one thorough inspection in the last five years.

That the inspecting engineers were unfavorably impressed with the whole plant and its method of operation is indicated by the following statement:

In view of the general unsatisfactory service under present conditions, it is probable that adequate fire protection for this city can best be secured through municipal ownership of all public water-supplies.

It would seem evident from the occurrences of this month, that conditions in the Vicksburg water-works have gone from bad to worse in the four years since the Board of Fire Underwriters presented its report. We apprehend that those who engage in circulating arguments against "municipal trading," as the English call it, would find very little sympathy in Vicksburg at present.

A $10,000,000 company was incorporated in Delaware on Sept. 20, to operate steamers and barges between St. Louis, New Orleans and New York City. The incorporators include some of the men who have been most active in the deep-waterways movement. Mr. W. K. Kavanaugh, of St. Louis, President of the Lakes-to-the-Gulf Deep Waterway Association, is to be President of the new company, Congressman Richard Bartholdt, Vice-President, and John L. Mathews, Secretary.

The general plan of the company is to operate a line of coastwise steamers between New York and New Orleans and a line of barges and tow-boats on the Mississippi between New Orleans and St. Louis. Transfer at New Orleans will be direct from the steamship to the barge. The barges used will be of three classes, the largest drawing 8 ft. of water and carrying 4,000 tons, the next 4 ft. of water and carrying 1,000 tons, and the smallest 3 ft. of water and carrying 600 tons. For the towboats special side-wheel steamers are to be built. The smaller barges are for service on tributaries of the Mississippi where the water is shallower. According to the newspaper accounts, the promoters of the enterprise state that 180 steel barges are to be built for the work, and the line is intended to be ready for business in the spring of 1910.

We trust the new company may be successful in securing the necessary capital. If the waterway promoters from whom the public has heard so much in recent years are right, there is "big money" in the business of inland transportation. And it has been abundantly shown that there is ample depth of water in the Mississippi from St. Louis down to carry boats deep enough to pay, if boating on the Mississippi will pay at all. There is no reason to believe that on a river with the bends and current of the Mississippi a boat drawing 12 ft. or 14 ft. can be operated with any substantial saving over one drawing 8 or 9 ft. It is therefore not necessary to wait for Congressional appropriations or Government bond issues. The Government has in fact spent and is spending millions of dollars to improve navigation below St. Louis during the season of shallow water. We hope the St. Louis scheme to utilize the present waterway and demonstrate its possibilities may be carried into execution.

Several enthusiastic inventors have attempted to exploit the scheme of constructing special highways for automobiles, but no one has come forward to furnish the funds necessary for so ambitious a program. The chief financial officer of Great Britain, however, in his new bill for British revenue, has announced a tax of about 3 cts. per gal. to be laid on gasoline, and has stated that a part of the revenue thus raised would be devoted to the construction of a system of special automobile highways, not open to horse vehicles and exempt from speed limitations—or at least with speed limitations different from those that obtain on ordinary highways.

It seems exceedingly doubtful, however, whether the amount of revenue which would be provided by this tax would be sufficient for doing anything practical in the development of automobile roads, since the latter promise to be enormously expensive.

Concerning Attacks Upon the United States Reclamation Service.

For some months past articles have been appearing in various newspapers reflecting upon the United States Reclamation Service. Definite criticisms have been lacking, other than the general statement that some of the methods adopted by the Reclamation Service were illegal, but the general tone and purport of the articles have been to throw discredit upon the officers in charge of the Reclamation Work.

A specimen of these newspaper attacks is an editorial published in the New York "Times" of Sept. 11. We reprint it in full as follows:

"GARFIELD CURRENCY."

Is Mr. Garfield, President Roosevelt's Secretary of the Interior, a Socialist? Did he do a Socialistic thing without the knowledge of his chief? The Washington Bureau of our neighbor "The Tribune" says this. The "cooperation feature" of the Reclamation Service which Mr. Garfield is responsible for consisted of Government receipts for work performed, credited against the amount due from settlers when water for irrigation should become available. President Taft's Attorney General has condemned it, "The Tribune's" correspondent says, as a "scheme to make possible the expenditure for irrigation of an indefinite sum in excess of the amount appropriated by Congress for that purpose." He quotes a United States Senator as saying:

It is precisely the scheme advocated by Bellamy in "Looking Backward," the issuance of a certificate of indebtedness in the name of the community (in this instance of the water-right company) in "acknowledgment" (payment) of labor performed, and redeemable in commodities—in this instance water.

But the Tribune Bureau is disposed to discredit the wide heralding of the Attorney General's decision with respect to the "Garfield currency" as upsetting a Roosevelt policy. "It was only a method and probably never came to the knowledge of President Roosevelt," it says. It was more than a method, it was an Administration policy, Socialistic, and in clear defiance of the law.

When you want to discredit anyone nowadays it is perfectly safe to call him a "socialist." There are so many forms of and definitions for socialism that it is useless to combat charges of that sort. It is not worth while, therefore, to answer the charge that ex-Secretary Garfield is a socialist. The "Times," however, goes farther and intimates that there was something illegal and highly reprehensible in the practice of the Reclamation Service which it denounces. According to the "Times" this practice was so bad that even those who might have been expected to defend it now disown it instead.

Before we accept this condemnation as final is not a little candid inquiry worth while? Let us understand the nature of this illegal, hideous "socialistic" and "Bellamistic" practice of which those in charge of the Reclamation work, from President Roosevelt down, were guilty.

To fully explain it, however, we must recall the law under which the Reclamation Service was established and is operating. That law provides that the entire cost of any piece of work is to be paid for ultimately by the land owners who receive the benefit. The payment is made, not into the general fund in the Treasury but into the special fund for Reclamation Work, so that as fast as the money is paid in it becomes at once available to build more Reclamation Works. The settlers can pay for the work either all at once or in annual instalments extending over a series of years. Now if it is for the public interest that the Reclamation Work shall go forward as rapidly as possible (and we believe no one questions this) then the sooner the settlers on a project pay for it, the better.

Suppose now a settler on a Reclamation Project desires to do some work in connection with the construction to occupy the spare time of himself and his teams while he is waiting to receive water on his land. Evidently, there can be no possible objection to this. The labor must be furnished by some one, and there are practical advantages in employing permanent residents, where they are willing to work, instead of the wandering nomads who usually constitute the laboring forces on construction work in the West.

So far, so good. But suppose the settler wishes, instead of being paid in cash for his work, to have it credited to him against the payments which he will shortly have to make. Is there any objection to this course? We can conceive of none. The United States is not running in debt—as might be speciously claimed—for Congress itself has ordered that the United States shall do the work for the settlers and that the payment for the work must sooner or later be made by them. If they desire to pay sooner instead of later, is there any reason why they should not have the privilege? On the contrary, is there not every reason why the privilege should be granted to them? Perhaps it may be at this point that the "socialism" creeps in; but if the Senator or the "Times" calls this socialism, they are welcome to make the most of it.

And now let us go one step further. Understand that strong pressure is brought to bear upon the Reclamation Service to undertake and push forward new works. It is perfectly well known that the amount of work the Service has been able to do and the rate of progress it has been able to make have been limited by the means available. The Reclamation Fund is made up solely of receipts from the sale of public lands and from the payments made for work accomplished.

Among the pressing appeals from localities where work is desired to be undertaken, there come appeals from settlers who are willing to cooperate in making the draft on the Fund as small as possible by paying for part of the work as it goes along.

The officials in charge under the last Administration gave heed to these appeals and worked out a plan by which such cooperation was possible and was effectively carried out on certain Reclamation projects. Without taking space to explain all the details of this plan it may be said that in substance it amounted to this: instead of the Government doing certain work and collecting the cost thereof from the settlers in the course of years in annual instalments, the work was done by or was paid for by the settlers and was credited to them by the Government on their payments due a year or two hence.

These "certificates of indebtedness" were *not* issued by the Government, as the "Times" intimates. To avoid any possible conflict with the letter of any law, they were issued by the Water Users' Association incorporated under the project, and the Government merely agreed to accept them at face value in payment for the instalments due on the work next year or the year after.

Was anyone injured by this plan of operation? Not the settlers. It was because of their urgent appeals and for their benefit that the plan was worked out. Not the settlers elsewhere in the arid region where irrigation was desired, for the Reclamation funds were husbanded because of this plan, so that more work could be undertaken. Not the United States Treasury, for the Government received payment *in advance* instead of waiting a year or two or three for the return of the money. More; the Treasury actually gained, for the annual instalments paid by settlers under a Reclamation Project do not bear interest.

The "Times" professes to find something "socialistic" and objectionable in this form of cooperation between the Government and the settlers. If the "Times" will pursue its studies of the Reclamation Act further, it will find that it is the very essence and idea of the Reclamation Act as passed by Congress that there *should* be cooperation between the Reclamation Service authorities and those whom their work is intended to benefit. The plan above described was merely an extension of the cooperation provided in the law.

Nevertheless it was of course possible that the plan might be illegal or might transgress some existing statute. Those in charge of the Reclamation Service under the last Administration were not unmindful of this. Every possibility where abuse of the privilege might arise was canvassed and the principal legal authorities in the Interior and State Departments were consulted and their approval was secured in order

that the question of legality might not arise. The plan was even submitted to a committee of the Senate and received the full approval of that body before it was put into operation.

But the "Times" says that Attorney-General Wickersham has "condemned" the plan; by which is meant doubtless that it is in his opinion unwarranted by existing law. This merely shows, however, to what extent the opinions of eminent lawyers may disagree. The "condemnation" does not extend to the merits of the plan. And the Attorney-General's opinion, given weight though it is by his present position, does not *prove* the practice to be illegal. The courts alone can settle the question whether the practice is within the letter of the law; and any intelligent private citizen, conversant with all the facts, can form his own opinion as to whether or not the practice is in accordance with the spirit of the law as enacted by Congress.

We are led to give considerable prominence to the above absurd attack by the "Times" upon the Reclamation Service and upon ex-Secretary Garfield—one of the most capable and progressive cabinet officers the nation has ever had—because it appears to have become the fashion recently in a portion of the public press and perhaps in certain official circles at Washington to slur the Reclamation Service and those who have built it up. We say "slur" because this is the method of attack adopted, of which the above quotation from the "Times" is an example. And such a campaign of innuendo merits the contempt of every good citizen.

No one can object in the slightest to fair and candid criticism of the Reclamation Service or of any other Government Bureau. But let us have fair criticism and be done with slurring. This we know: that the Reclamation Service has done things. Very likely it may have made mistakes. No man and no organization ever accomplished anything worth while without making some errors. But the public will base its judgment upon the final large results; and these results are so important and so vital to the public welfare that the public could well afford to overlook many large mistakes even, if that were necessary. And no such mistakes have yet been brought forward.

We believe we may go a step further and say that the engineering profession throughout the United States believes in the Reclamation Service, and holds those who have built it up to be deserving of high honor. It stands to-day as the greatest organization of civilian engineers in the Government service. The profession has entire confidence that the organization is conducted on absolutely honest and non-partisan lines and with efficient public service as its sole aim.

It used to be said that it was impossible in this country for the Government to carry out the construction of public works on a large scale under the direction of civilian engineers. Inevitably politics would creep into the work; engineers would be appointed because of political influence and would be compelled to favor contractors possessed with similar pull. The final result would be an organization filled up with loafers, incompetents and grafters, and the work done under their direction would be both defective and costly.

The engineering profession and the country owe a debt to Mr. Frederick H. Newell, M. Am. Soc. C. E., Chief of the Reclamation Service, for proving the falsity of that old idea. With the cordial cooperation and backing of President Roosevelt and Secretary Hitchcock, and his successor, Secretary Garfield, Mr. Newell and his associates have built up the Reclamation Service on the basis of non-partisanship and business efficiency. This very matter of cooperation with the settlers in permitting them to pay for their work in advance is an illustration of the manner in which the same common-sense business methods that would be used in a well-managed private business have been applied to Government work in the Reclamation Service.

If the enemies of the Reclamation Service think to discredit its work and its leaders in the public mind by criticising such procedure, they will find their mistake. The public will be rightly suspicious of this remarkable zeal to protect the letter of the law and will make a shrewd guess at the motives behind these published slurs upon the Service.

At Grand Junction, Colo., the people have seen the work on a Reclamation project of great importance to them stopped indefinitely because of the new ruling forbidding the former cooperation between the Government and the water users. The people there will not be satisfied with the explanation of the "Times" that their proposal to pay for part of their work is "socialism." They had rather have socialism that puts water on their lands than red tape that leaves them in the desert.

And the engineering profession will have to hear some sounder criticism of the Reclamation Service before it will abate its confidence in Mr. Newell and the engineers associated with him.

LETTERS TO THE EDITOR.

Simpler Formulas for Reinforced-Concrete Beams Wanted.

Sir: In looking over various publications on reinforced concrete one will hardly escape being impressed by the variety of assumptions made and results derived.

For example, on pp. 305 and 306 of Reid's "Concrete and Reinforced-Concrete Construction," which is one of the best books published on the subject, six different values ranging from 6 to 20 for the ratio of elasticity between concrete and steel; 20 different values ranging from .001 to .05 for percentage of steel reinforcement; three values ranging from 12,000 to 20,000 for working stress in steel; and three values ranging from 400 to 600 for working stress in concrete are assumed in deriving various values ranging from 11 to 204 for the coefficient K in the equation $M = K\,bd^2$. These are certainly wide limits within which individual judgment may run riot and be justified in producing reinforced concrete designs of amazing variety in proportion and quality of ingredients and in finished dimensions, any one of which will, on the assumptions made, satisfy the conditions and answer the particular requirements of the structure under design.

For the comparatively small quantities of concrete in well designed reinforced work I do not believe that there is sufficient economy in adopting anything less expensive than the standard 1:2:4 mix to justify complications and, doubtless, uncertainties introduced by running at large within the limits above indicated. Moreover I believe that there are a needless number of assumptions relative to first-class 1:2:4 concrete.

In the interest of simplicity and safety I suggest the use of such concrete with a ratio of elasticity between steel and concrete of 12.5; a working stress of 12,000 lbs. in steel, and a working stress of 600 lbs. in the extreme fiber of the concrete. With these assumptions we can derive the four necessary working formulas as follows:

$$M = 100\,bd^2$$

$$d = \sqrt{\frac{M}{100b}}$$

$$b = \frac{M}{100d^2}$$

$$a = \frac{M}{10{,}000d}$$

in which

M = the moment,
d = the depth of beam from center of steel to top,
b = the breadth of beam,
a = the area of steel reinforcement.

It should be noted that the exact statement of the last equation should be,

$$a = \frac{M}{10{,}462d}.$$

The numerical value is made 10,000 for simplicity and because it gives a value well within the variation that must be accepted in selecting market sizes of reinforcing rods. It will also be found that this equation gives a 1% reinforcement within an insignificant fraction.

In deriving the above equations it was assumed that the modulus of elasticity of steel is 30,000,000, and of the 1:2:4 concrete 2,400,000; and that the crushing strength of the concrete is 2,400 lbs. per sq. in. It may be objected that such concrete will attain higher values and, while this is perhaps true, it may readily happen that, in general work, these values will not be exceeded or that the structure will be fully loaded before they are exceeded. Exception may also be taken to the low stress of 12,000 lbs. in steel, but this is justified on the ground that it will permit the general use of plain round bars and will keep the neutral axis low. The strength and behavior of the very best concrete is not so unvarying that we can afford to venture habitually too near to the maximum that it is capable of attaining. I believe that the formulas above given will be found to be easily memorized, simple in application and quite reasonably economical for general use.

Yours very truly,
J. L. Campbell.

El Paso, Tex., Aug. 31, 1909.

[Practically identical results would be obtained by the still simpler method and formula advocated by several authorities on the basis of tests of beams to failure. Their method is founded on the observation that beams reinforced not over 1.25% will fail in the steel, so that the steel stress determines the moment capacity. The neutral axis in such beams is found to be located so as to give a lever-arm from centroid of compression to axis of steel approximating 0.85 to 0.87 of the depth. Then the moment capacity becomes

$$M = 0.85\,A\,f_s\,d$$

and A is to be limited to say 1.0%, but may be anything below this. With 1% reinforcement and $f_s = 12{,}000$, the moment coefficient is practically 100, as in Mr. Campbell's formula. This method is by far the easiest remembered and applied of any.—Ed.]

Experimentation with Hypochlorite of Lime as a Water Disinfectant at Warren, R. I.

Sir: The work of Clark and Gage, an abstract of which appeared in the Engineering News of Sept. 16, 1909, p. 302, on "Disinfection as an Adjunct to Water Purification" has called to the writer's mind the desirability of placing upon record all material bearing upon the use of hypochlorite in connection with water supplies.

The portion of the paper above referred to which prompted the writing of this letter is the part bearing on the use of bleach in combination with sulphate of alumina in mechanical filtration. While taking no exception to the statements and conclusions there made, as being facts in connection with a polluted water of the character of the Merrimac River, the conclusion given might be apt to mislead the casual reader and leave the inference that the simple addition of bleach will invariably reduce the cost of purification in any mechanical filter plant purifying a water by the use of sulphate of alumina and soda.

In connection with the handling of the water from the Kickemuit River in Warren, R. I., by the Bristol and Warren Water Co. in its new mechanical filter plant, the writer, representing the R. I. State Board of Health, with Messrs. Robert E. Milligan and N. C. Nicol, of the N. Y. Continental Jewell Filtration Co., had occasion to investigate the possibility of saving sulphate of alumina and soda by the introduction of hypochlorite of lime. The raw water at this plant is high in peaty organic matters and comparatively low in bacterial count. The use of large amounts of sulphate of alumina is necessary at times, the dose occasionally being as high as 2.5 grains of 18% alumina to handle the color satisfactorily and to insure a slight margin of safety for operation. The color in the reservoir never drops low enough to allow of the use of less than 1½ grains of coagulant to insure a water of satisfactory color, that is a color that can be maintained consistently below ten parts per million on the platinum standard. These doses always insure a satisfactory bacterial efficiency and 98 to 99% efficiency can be maintained using the minimum dose which is sufficient to handle the color.

With the plant operating at a dose of 1.8 grains sulphate of alumina and delivering a filtered water of 10 color, an attempt was made to drop the dose. A reduction of 0.2 grains per gal. proved to be sufficient to give an increase of four or five points in color in the effluent. It was decided to introduce hypochlorite of lime in a fairly moderate dose to see if there would be any material effect on the color of this water, and if so, if thereby a saving in alumina and soda could not be effected which would more than offset the cost of the hypochlorite. Accordingly hypochlorite of lime was introduced in a dose equivalent to 0.6 of a part per million available chlorine and the plant operated as before with a dose of 1.8 grains sulphate of alumina. The color of the effluent was no better operating under these conditions of combined dosing. Attempts to cut the dose below the point which was found to be the critical point when operating without hypochlorite were unsuccessful.

Operating under either of the above conditions satisfactory results as to bacteria were obtained and *B. coli communis* was consistently absent from the effluent.

The following conclusions seem to be warranted from the above work:

1. While the introduction of hypochlorite of lime allows a reduction of the dose of the coagulant when the problem is the purification of a water of low color highly

polluted bacterially, the same is not true when the problem is reversed and a water high in peaty color but low in bacteria is to be handled.

2. In the case of waters high in color hypochlorite of lime, at least in doses up to 0.6 of a part per million available chlorine, has no material effect on the operation of a mechanical filtration plant as far as the color of the effluent is concerned, provided the dose of sulphate of alumina is sufficiently high to maintain a color in the effluent below 10.

3. With dark colored, peaty waters the above dose of hypochlorite of lime is not sufficient to effect any material color removed.

Yours very truly,

Gilbert H. Pratt,
Chemist R. I. State Board of Health.

Providence, R. I., Sept. 23, 1909.

The Accuracy of Engineering Graduates.

Sir: In reference to Mr. Newbrough's letter in your issue of Sept. 16, 1909, concerning the lack of accuracy in the work of college or university graduates, and suggesting that the fault lies in the training or instruction, I desire to offer a few suggestions in defense of the university training.

Being a university graduate myself I feel that these remarks will be true of at least one school, and most likely of many others.

Our instruction placed strong emphasis on *accuracy* as well as on *methods*, but some students paid little attention to these instructions. We were taught that if a person used correct methods and was not accurate, then his methods would count for nothing in accomplishing results. Since a university training is for the purpose of teaching how to get results, that would be a poor training indeed which did not teach equally the necessity of being accurate as well as that of using the correct method.

I would suggest that the fault which Mr. Newbrough finds, is more the fault of the man than of the training. Many students attend the university as much for pleasure as for instruction. These students go through school with passing grades and not much more. Many of them depend upon absorbing the subject without faithful attendance at recitations or lectures, so of course they fail to get the benefit of the instruction relating to accuracy. When it comes to practical work, they try to use the slip shod methods that they used at school and finding that these methods will not work, they try to lay the blame upon their instruction, and say that they were not taught to be accurate.

I do not mean to infer that this is true in all instances, but I believe that it is true in many instances similar to those related by Mr. Newbrough.

Yours truly,

Wm. C. Perkins.

Plattsburg, Mo., Sept. 21, 1909.

Sir: Mr. W. Newbrough's letter in your issue of Sept. 16 is pertinent. It is high time that some revision take place in the methods of instruction at the engineering schools. The writer feels confident in saying that the average engineering graduate of to-day, (including in this average at least nine-tenths of the total number) can be relied upon, after about a month of field experience, to fully comprehend, so far as methods go, the work that he is assigned to, to the extent of going off on his own resources and doing the work without direct supervision. In nine cases out of ten, however, the numerical result cannot be accepted with confidence.

Within the past year and a half, the writer has employed 31 graduate engineers, about 24 of whom were out of college less than a year.

The disheartening truth gradually dawned upon the writer that scarcely one of these men could be relied upon not to make radical errors, and if the number of check lines that have been run and all of the letters that have been written enjoining more care in addition and subtraction were listed, it would be a sad commentary upon the engineering schools.

One graduate spent a week looking for errors in his level lines in a desolate swamp, and when his original notes were sent to the office and checked, glaring errors in arithmetic were found in them, uncorrected!

This is only one of many similar occurrences.

The office clerk, 18 years old and equipped with a business education only, could be relied upon with absolute confidence when he pronounced a bill or pay-roll correct in arithmetic. Many is the error that this clerk found in the accounts sent in by engineers of from one to ten years' experience.

And yet this corps was, on the whole, an excellent set of engineers, as young engineers go. Honorable, energetic, ambitious, willing to go into rough and thorny places—lacking only an appreciation of the importance of Precision, without which the work of an engineer is worthless unless checked.

An inexperienced college graduate should never be relied upon to make a survey and report a correct result until his work has been checked, cross-checked and re-checked.

A. L. Dabney, M. Am. Soc. C. E.

Clarksdale, Miss., Sept. 20, 1909.

[Query: May not the original responsibility for the weak arithmetic of present day college graduates lie with our common schools? Are the methods of teaching arithmetic to-day as good as those in vogue half a century ago? Certainly the results appear to be inferior. The boy who enters college ought to know his arithmetic perfectly, not only as a science but as an art. Undeniably the engineering school ought to impress upon its students that correct arithmetical work is even more important than expertness in higher algebra; but if the boys coming up to the college to enter were competent in arithmetic there is no reason why they should deteriorate as a result of their four years training in engineering.—Ed.]

John Stevens' Work in the Development of the Steamboat.

Sir: At a time when we are celebrating the fame of Robert Fulton, of Pennsylvania, and acclaiming him as the one man connected with the introduction of steam navigation upon the Hudson River, why is it that we hear little or nothing of John Stevens, of Hoboken?

Fulton was certainly a great inventor and is credited with having experimented with paddle-wheels at a very early age; but his name is not connected with propulsion by steam until about 1793; while John Stevens was actively working in that direction as early as 1788.

About the close of the eighteenth century the Legislature of New York offered the exclusive privilege of navigating the Hudson River by steam to any one who would construct a steamboat meeting certain fixed requirements of speed. In an attempt to secure this monopoly, John Stevens, his brother-in-law, R. R. Livingston, and Nicholas I. Roosevelt, about 1800, actually built a steamboat and tested it upon the river; but it failed to make the requisite speed of three miles per hour. Just afterward, or in 1801, Mr. Livingston was appointed Minister to France, and his departure interrupted for a time the steamboat experiments. In Paris, Mr. Livingston made the connection with Fulton that resulted in the building of the "Clermont," some years later.

But John Stevens, and his son Robert, were still working upon the problem of steam propulsion; and it is not generally known, says the late Prof. James Renwick, that in the famous trial of 1807—when the "Clermont" won, the Stevens were only a few days late in presenting for that trial a paddle-wheel steamboat which equally met all the requirements fixed by the legislature. This was the steamboat "Phoenix," built by Stevens in 1807. Barred from the waters of the Hudson by the exclusive privileges awarded to Fulton and his associates, as a result of the success of the "Clermont," Stevens concluded to run his boat on the Delaware River, and it was used on that stream for about six years. To get the craft into the Delaware, however, was a problem, and Stevens finally adopted the bold plan of sending the vessel to sea to make the voyage from New York to the entrance of Delaware Bay. The voyage was made with success under steam, and to the "Phoenix," therefore, is due the credit of being the first vessel to navigate the ocean by steam power.

John Stevens also invented the screw-propellor. In 1804 he constructed a vessel propelled by twin-screws which navigated the Hudson River for a time. He used a tubular boiler and his screw was practically identical in form and thread with that used on the largest steamships of the present day. From the beginning John Stevens contended that the screw was a more efficient means of propulsion than the paddle wheel; a contention only recognized a generation later. To him, too, is due the credit of building the first steam ferry-boat.

While the writer was born within a few miles of the birthplace of Robert Fulton and is proud of him as an inventor and a Pennsylvanian; it seems only fitting that at this time John Stevens, of Hoboken, should have fuller recognition than has yet been awarded him by his fellow-citizens of New York.

Very truly,

D. McN. Stauffer.

Yonkers, N. Y., Sept. 24, 1909.

A Question in Concrete Mixing.

Sir: I would be pleased to submit the following relative to a concrete mixture, for views from readers of your journal.

A certain specification reads:

Before beginning construction, the engineer in local charge shall determine the voids in the crushed stone or gravel which is to form the aggregate of the concrete. The proportion of mortar which is to form the matrix of the concrete may be varied slightly if necessary in order that it shall exceed the natural voids by 20% of the total mass of the loose aggregate. This proportion shall be used until a change in the character of the aggregate may require a slight variation in the proportion of mortar. The concrete in question shall be composed of one part cement, two and one-half parts of sand, and five parts of gravel or broken stone.

The cement is found to measure 1 cu. ft. to the bag, the voids in the sand are 30%, and the voids in the gravel are 35%.

With this data, what quantities of sand and gravel are to be used for each bag of cement (1 cu. ft.)? What is meant by the aggregate? Is it the broken stone and gravel, or is the sand included too?

Yours truly, "Concrete Mixture."

Chicago, Ill., Sept. 22, 1909.

[Aggregate in concrete means the stone or gravel as distinguished from the matrix or mortar of sand and cement. In this case it is evidently the intention to ensure that the mortar is sufficient in volume completely to fill the voids in the stone, hence the insertion of the 20% excess volume clause. Experiments have shown that about 40% excess is necessary for a certain filling of the voids, especially in a dry concrete, but evidently the engineer in this instance considered 20% sufficient.

In regard to the above materials available to satisfy the specification, it would seem that the 1:2½:5 mixture specified as a minimum could be used. With these proportions, assuming the use of 2½ cu. yds. of sand, it would take $0.30 \times 2\frac{1}{2} = 0.75$ cu. yds. of cement to fill the voids, thus leaving 0.25 cu. yds. excess cement paste and a total volume of mortar of $2.5 + 0.25 = 2.75$ cu. yds. Of the 5 cu. yds. of stone to be used, $0.35 \times 5 = 1.75$ cu. yds. are voids, to be filled by the mortar. This leaves $2.75 - 1.75 = 1$ cu. yd. of excess mortar, which is more than the prescribed 20%. Hence it is not necessary to increase the proportions over the minimum 1:2½:5.—Ed.]

A Problem in Long-Distance Pumping.

Sir: During the construction of the Nashwauk Extension of the Great Northern Ry. this last winter, one of the sub-contractors met and solved a water-supply problem in a way that caused much comment. He desired to pump water from a creek (elevation of surface, say, 3,000 ft.), up about 5,000 ft. of fairly gradual slope, to a tank, elevation 3,050 ft. Using 1½-in. pipe, laid along the ground, the pump stalled in a futile effort to put any water to the outlet. The contractor then went ahead and erected a tower about 300 ft. from the pump, just a four-legged stand of tamarack the top of which stood 10 ft. higher than the outlet, elevation, 3,060 ft. Over this tower the 1½-in. pipe was carried, leaving the ground 50 ft. from the tower and returning to the ground 50 ft. on the opposite side. So the only change from the first arrangement was that aerial loop, 60 ft. up and back to the original line. The contractor got water, but in the meantime had repaired his pump, leaving us without conclusive proof either way. I do not see where any advantage could be gained, since both the total friction and total head seem to have been increased by the added pipe. Will you offer an opinion, explaining why?

Yours truly,

J. W. Wynn.

Nashwauk, Minn., Sept. 7, 1909.

[It is not surprising that the pump refused to deliver water through so long a delivery pipe of such small size. If the contractor had placed a tank on top of his tower and delivered into that, it would be easy to see the advantage, since the tank would give a uniform head upon the force main, whereas the pressure of the pump is variable, notwithstanding the equalizing action of the air chamber. It is possible, even if the aerial loop of pipe was only of the same size as the rest of the pipe, that it had some effect in equalizing the flow; but it would seem the more probable supposition that the power of the pump was increased by the contractor's repairs.—Ed.]

The Fine Grinding of Cement.

Sir: I have read with interest the letter in your issue of Aug. 26, 1909, p. 230, on "Fine Grinding of Cement as an Indication of Strength," and I agree with Mr. Hartranft that the tensile strength of 1:3 mortar is the best indication of the efficiency of a cement which is available in the *present state of our knowledge* of the subject, but this test shows the net result of all causes of variation, including chemical composition and thoroughness of burning as well as fineness, and it does not indicate the

effect of any one of these causes separately. A series of tests on eleven brands of cement in the Kansas City market show similar results to the Philadelphia tests, and an inspection of any series of tests on standard grades of cement will lead to the same conclusion, viz., that the variation in strength is due to other causes than the difference in fineness; in other words, that the variation in fineness is not great enough to be the controlling factor in determining the strength. When, however, these standard brands are compared with a cement

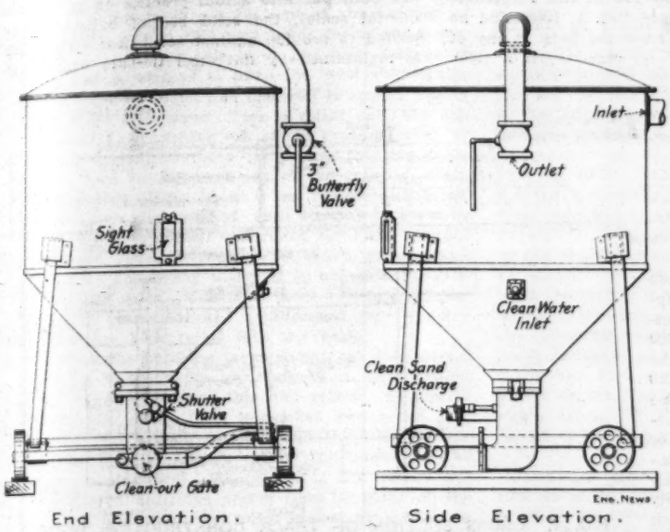

FIG. 1. ELEVATION OF SAND WASHING CYLINDER.
(E. M. Nichols, Philadelphia.)

ground so fine that 85% instead of 75% will pass a No. 200 sieve, the difference is so great that its significance cannot be misunderstood.

It is only within the past year that a superfine cement has been obtainable in the Kansas City market, and no long series of tests are as yet available. Taking an average of all the 28-day tests on 1:3 mortar with this cement of which I have a record, the results are: Fineness, 85.3% through a No. 200 sieve; tensile strength, 454 lbs. per sq. in. The average of all the tests on the nine brands in the table published in your issue of Aug. 26 is: Fineness, 76.3% through a No. 200 sieve; tensile strength, 323 lbs. per sq. in. This difference of 40% in strength for only about 12% increase in fineness, is probably due to several causes; first, the increase in the percentage of what is commonly called "impalpable powder" is much greater than the difference shown by the No. 200 sieve; second, the raw materials for this cement are ground unusually fine before burning, thus producing a high grade of clinker; third, accidental causes of variation may have made these few tests average higher than will be maintained over a period of several years. Now the point I desire to make is this: If the effect of variation in fineness were fully known, a correction could be applied to these tests, reducing them to the equivelent of some standard grade for comparison, and they would then indicate the true quality of the clinker before grinding. I certainly think it is worth all the effort that may be required to devise an accurate method of determining fineness, in order that we may know how much of the difference in strength is due to this cause and how much to other causes. Fine grinding does not affect the *quality* of cement but increases the *quantity* of actual cement per barrel, therefore its effect could be easily determined if we could measure the percentage of "impalpable powder" contained in the sample.

Very truly yours,

Kenneth Hartley.

1500 Grand Ave., Kansas City, Mo., Sept. 3, 1909.

Notes and Queries.

The present relations of supply and demand in the lower grades of engineering work are illustrated by the results of a recent advertisement for a rodman in our "Situation Open" column. The salary offered was only $45 per month, but the place was attractive on other accounts. The advertiser reports that over 60 applications were received in reply to the advertisement.

D. R. C., Albany, N. Y., writes:

I am interested to know whether the old water-wheel in the yards of the Burden Iron Works at Troy, N. Y., is the largest in the United States, its diameter being 60 ft. If not, will some one inform me as to what is the largest wheel and where it is located? I am informed that there is a wheel 72½ ft. in diameter on the Isle of Man, but up to date have received no information of any wheel larger than the Troy wheel in the United States.

Development of Devices for Cleaning the Sand of Slow Sand Filters.

By E. M. NICHOLS,* C. E.

In the operation of slow sand filters for the purification of water, one of the most important items, and at the same time the most expensive, has been the cleaning of the sand as it becomes clogged. The need of an apparatus, low in first cost, effective in results and capable of being operated without regard to weather conditions, is therefore pressing. This is especially true for large stations where such apparatus would make possible smaller reserve areas, and would lower the first cost of construction or would increase the capacity of plants already constructed.

The original method of wheeling sand from the filter beds to a box and washing with a hose, while raking or stirring until the overflow water showed clean, has in most cases been superseded.

The first important advance, in mechanical devices, was the Greenaway machine—a revolving cylinder partly closed at the ends and revolving in a box supplied with running water. The sand was shoveled into one end of the cylinder and gradually worked its way to the other, becoming cleansed during its passage and dumped outside of the box in barrows and cars and moved to some suitable storage bin. This device, while effective in cleaning the sand, was expensive to operate.

The next departure was the use of sand ejectors. The apparatus consisted of a series of hoppers, into the first of which the dirty sand was shoveled. An ejector, consisting of a water jet and sand discharge throat, was placed in the bottom of each hopper. The sand was carried up through a pipe from one hopper to another by the rush of water. As enough water was supplied to make a considerable overflow from the hoppers, there was a certain amount of cleaning in each one. By the time the sand had passed through three or four units the foreign matter was generally all carried off by the overflow. From the last hopper it was ejected up to a storage bin where it remained until it was required to replenish the sand as beds became shallow.

Later ejectors were employed to remove the dirty sand from the beds, being made portable in construction and connected by means of flexible hose lines with the water pressure or sand discharge lines erected in the beds. The sand was shoveled directly into the portable ejector and carried by the water to the washing hoppers outside of the beds. This method, with various modifications and different designs in construction has been generally used, but with very slight reduction in cost of labor or in volume of water wasted, the latter ranging from 12 to 20 volumes of water to one of sand handled.

Another machine has been designed combining a mechanical scraper with an ejector but, so far, the cost of its construction, operation and maintenance has not permitted of its extensive application.

In all these cases it has been found necessary to periodically remove, clean and restore sand to the beds, and not only was this a large item of expense, but it required that a portion of the plant should be out of service for some time, making a large reserve area absolutely essential. Mechanical means of restoring the sand have been employed, but so far the cost has not been reduced and, if anything, has been increased. The cost of cleaning has been reduced somewhat by the practice of raking the dirty top sand on the bed while a stream of water about 6 ins. deep flowed over it. This removed a larger part of the accumulated mud, but it was found to have gradually colored the sand to a depth of 5 or 6 ins. when the sand was removed and thoroughly cleaned.

FIG. 2. THE NICHOLS SAND CLEANING APPARATUS IN USE.

*212 South Seventh St., Philadelphia, Pa.

During the season of 1908 the writer conducted some experiments in the hope of evolving a simple method for cleaning the sand that would reduce the cost of this item of maintenance. It was decided to endeavor to clean the sand without removing it from the beds, and at the same time to use the system of water-pressure and sand-discharge lines already installed. At an early period of the operations a cylinder with a conical bottom, built closed, so as to permit its operation under pressure, was adopted and from the start excellent results were obtained in separating the sand from the dirty water and depositing the former in a very clean state. Various obstacles of operation were met, but finally overcome, and it is now being used successfully in cleaning the sand with practically no loss, delivering it without segregation and using only five or six volumes of water instead of 18 or 20, as required under the old methods.

The operation of the device is easily understood by referring to the accompanying figures. The dirty sand is shoveled into the hopper of a portable sand ejector from which it is delivered into the separator at the side near the top. The main discharge, of waste water and mud, is carried to the court or to a sewer outside of the filter beds. This discharge comes from the pipe which is connected to the top of the cylinder and which may be merely cut into the discharge line of the original system.

An arrangement of baffles in the interior of the cylinder, or "separator" as we have called it, throws the sand down to the bottom while the mud is carried away from it by the rising current of water. The cleaned sand is carried off through a hose and deposited on the bed in a comparatively dry condition. There is with it only the 7-10% of water needed to give fluidity. No water shows on the surface of the sand as deposited, except in case of carelessness or accident, and the sand coming from the hose generally appears as a continuation of the hose.

The sand is deposited in little piles which, as they drain dry, are leveled off by the operator, leaving the surface of the beds level and uniform.

The separator weighs about 700 lbs. and is easily handled by the regular scraping and removing force. It is bolted to a truck frame and as it runs on channel rails bolted to 2 × 6-in. planks resting on the sand bed, it can follow up the ejector very closely, generally using 20 or 25 ft. of hose. One marked result was observed; the delivery of the ejector was increased by some 15% to 25% by using the separator within 25 ft. of the ejector instead of forcing the sand from 200 to 350 ft. Another curious phenomenon was observed. The proportion of the mixture of sand and water in the separator had an important effect on the amount of sand carried over by the waste water—even when the velocity was reduced. An increased proportion of sand, beyond a certain point, increased the volume of sand lost fully 100%. This point was not determined precisely, but five or six volumes of water to one of sand was found to be about the best ratio.

With a water pressure of 80 to 100 lbs. at the nozzle of the portable ejector the capacity of the 42-in. separator is about 12 cu. yds. per hr., that of the 36-in. machine about 9 cu. yds., and of the 30-in. machine about 5 cu. yds.

The device has been in use at the Torresdale plant of Philadelphia since Dec. 1, 1908, and no sand has been removed from the beds at any of the four plants of that city since April 1, 1909. Bacteriological records show its value in keeping the beds in an efficient state for the removal of bacteria. The percentage remaining in the effluent on starting up the beds, after scraping and cleaning, has been decreased. With an applied raw water containing 9,000 to 12,000 bacteria per c. c., the count seldom exceeds 120 per c. c. during the first 48 hours, and immediately drops to 40 or less. This renders it unnecessary to waste any water, whereas formerly the nature of the effluent was such that it had to be wasted for quite a period. Aside from this, keeping the beds at a uniform depth aids in efficiency of filtration.

At another city the device was used for washing the entire sand bed of each filter, which had become clogged and dirty through its entire depth, 3 to 4 ft. In these cases the effluent water showed for the first 24 hours a somewhat higher percentage of bacteria and then immediately dropped to normal. This was in marked contrast to the former practice when washed sand was replaced to depths of 18 or 24 ins. and the effluent was wasted for several days. In this particular plant the entire cost of washing and replacing by means of the separators is shown in the accompanying table. The above conditions should be remembered in considering the data on bacteria shown.

The writer claims several points of advantage resulting from the use of this washer: (1) cheapened first cost of cleaning apparatus, (2) lower cost of sand cleaning, (3) no beds held out while sand is being removed and restored, and a consequent possible reduction of total area of filter service, (4) original quantity of sand required reduced by some 1,500 cu. yds. per acre, (5) elimination of cost of outside handling of sand, (6) reduction of wash water by 60%, (7) more efficient service from filter beds with practically no wasting of water to sewers, (8) increased output of existing plants.

RECORD OF USE OF NICHOLS SAND WASHERS.
Cleaning Entire Sand Bed of Two Slow Sand Filters, Fouled for Entire Depth.

FILTER A.

Sand washed	2,000 cu. yds.
Depth of sand washed	42 ins.
Water pressure	60 lbs.
Volume of water to sand	6.41 to 1
Sand lost by separator	3%
Labor cost, washing and laying	21.5 cts. per cu. yd.

(Finished cleaning Aug. 1.)

	Bacteria in applied water, per c. c.	Bacteria in effluent, per c. c.
Aug. 2	81	2,150
Aug. 3	106	1,800
Aug. 4	102	341
Aug. 5	94	324
Aug. 6	127	87
Aug. 7	95	62

FILTER B.

Sand washed	3,213 cu. yds.
Depth of sand washed	32 ins.
Water pressure	45 to 60 lbs.
Volume of water to sand	
Sand lost by separator	1.5%
Labor cost, washing and laying	22.5 cts. per cu. yd.

(Finished cleaning Aug. 20.)

	Bacteria in applied water, per c. c.	Bacteria in effluent, per c. c.
Aug. 21	176	2,100
Aug. 23	168	370
Aug. 24	135	360
Aug. 25	224	307
Aug. 26	160	225
Aug. 27	130	189
Aug. 28	160	75

DRAINAGE OF THE KANKAKEE MARSHES in northern Indiana and southern Michigan is again under consideration and a report on the project has been made by a Board of Commissioners. It is estimated that 150,000 acres would be benefited and the total cost would be about $270,000. An early project for the same work was described in Engineering News of July-December, 1892, pp. 410, 421.

A New Design of Railway Track Construction.

One of the latest attempts at the improvement of railway track, and especially at the reduction of maintenance work and cost, has as its special features the elimination of cross ties and the reliance upon a deep and well-rolled bed of stone ballast to carry the load. In this system (which has been put into actual practice on an experimental scale), the solid bed of ballast is expected to provide against settlement. The gage is maintained by flat steel tie-bars which grip the base of each rail, and these bars are anchored in the ballast to preserve the alinement of the track. The rails are supported at the joints by short pieces of steel channels, but otherwise they bear directly upon the specially prepared ballast.

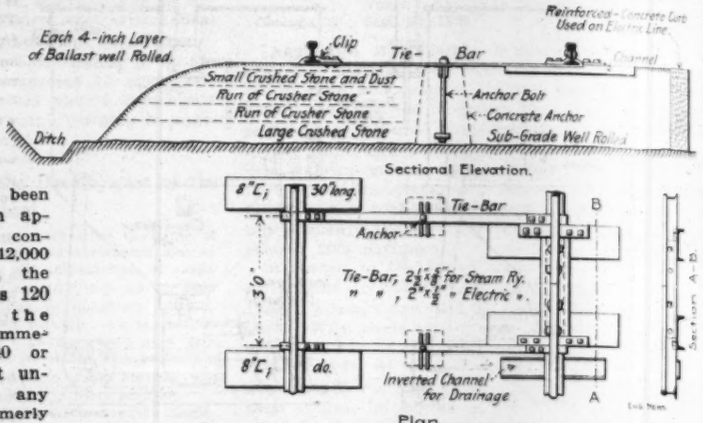

FIG. 1. CROSS SECTION OF TRACK CONSTRUCTION WITH A WATERTIGHT BED OF ROLLED STONE BALLAST.
W. H. Coffman, Inventor; Bluefield, W. Va.

The ballast (of whatever material) in ordinary track construction is porous; it sheds some and absorbs some of the water falling upon it, but allows the excess to soak through to the roadbed. A damp roadbed is slow to dry out, and its soft condition may lead to continual settlement of the track. In the new system, the compacted bed of crushed stone, well rolled, and with stone screenings used to fill the voids, is said to make a watertight mass which will shed the water and thus keep the roadbed or subgrade in a permanently dry and firm condition. The subgrade is rolled before laying the stone upon it. The construction is shown in Fig. 1, and the following description is condensed from that given by the inventor.

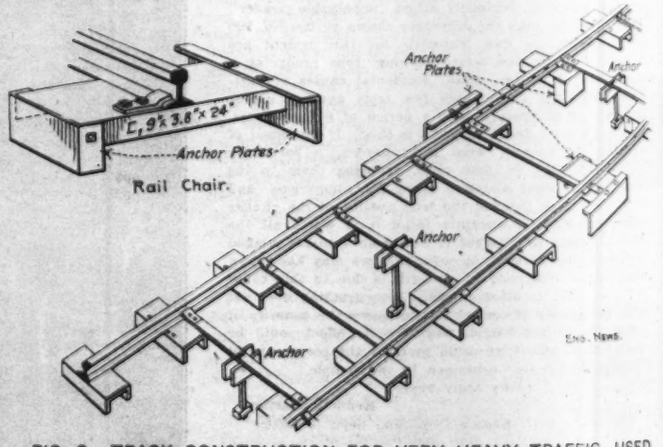

FIG. 2. TRACK CONSTRUCTION FOR VERY HEAVY TRAFFIC, USED IN CONNECTION WITH A HEAVILY ROLLED BED OF BROKEN STONE (AS SHOWN IN FIG. 1).
W. H. Coffman, Inventor; Bluefield, W. Va.

For heavy traffic the ballast should be about 18 to 24 ins. deep. The ballast material should be crushed limestone, which should be put on

in run-of-crusher sizes (no piece larger than 2½ ins.) to the thickness of 4 ins. for the first layer. Care should be taken that this layer is spread evenly and corresponding to the final surface. On a curve, the outer edge is made a little thicker. If the ground is solid where this 4-in. layer is put on, it is rolled with a 10-ton roller; but if the ground is not solid, it is better to use a lighter roller. The stone is rolled until the voids are as small as possible.

An estimate should be kept of the amount of material put in this first layer for a given distance, and when this layer has been compacted in such a way as to have the least void space, then 25% as much fine material is spread evenly over the 4-in. layer. This is rolled until the fine material (consisting of sand, crusher dust or furnace slag) has been compressed into the voids and does not show on top of the crushed stone. Measuring blocks about 4 ins. square and 4 ins. thick are then placed, and another 4-in. layer of ballast is spread and rolled until the amount of void space is reduced as much as possible; 25% of fine filling material is added and rolled into the voids. The layer next to the top layer should be wetted and well rolled after the dry filler has been rolled into the voids.

Then the finishing layer is put on; this should be 1½-in. limestone, and some ¼-in. stone should be mixed on top of this and rolled. An ample quantity of the filler is applied and rolled dry, after which it is watered and rolled in a very vigorous way, always rolling the outer edge of the roadbed first. The watering and rolling are continued until the water runs in front of the roller, and until the roller makes no marks on the roadbed. When finished this roadbed is watertight and will shed water.

The rails should now be laid on blocks 8 to 10 ins. long and 4 ins. high, and the steel tie-bars put on the rails. For electric lines, an 8-in. channel 24 ins. long should be bolted to the rails to support the joint. The track should be lined up in this position before it is let down upon the roadbed. There is a hole in the center of each tie-bar and under this hole a recess should be cut in the roadbed, 12 ins. square and 15 ins. deep, and all the loose stone is scraped from the edge of this hole. After this recess has been cut, the track can be lowered onto the roadbed.

A crowbar should be used to make slots in the roadbed so that the legs of the channel bars will settle in the stone and allow the face of the channel to rest directly on the stone surface. At each of the steel tie-bars a small amount of the stone should be removed to allow the bar to imbed itself in the roadbed, allowing the rail to rest solidly on the roadbed for its full length. The track should now be lined, and the anchor bolt should be hung in the recess previously made, with a large washer on the lower end. Then the material that was dug out should be mixed with cement and a little sand, and put into this recess to form a concrete anchor.

The anchors are to hold the track in line. The tie-bars should be about 3 ft. apart., or 4 ft. on tangents and 2½ ft. on curves. The channel bars are 8 or 9 ins. wide, and not more than 24 or 30 ins. long. They have clips to hold both sides of the rail, and at the joints these clips engage with the splice bars to prevent creeping. On curves, two additional channel supports (with or without clips) may be placed under each rail, between the joints. This roadbed system of construction is said to cost only about 24 cts. per ft., or $1,267 per mile (exclusive of rails and fastenings). The maintenance is estimated at $5 per mile per month.

This track construction was laid in December, 1908, on about 100 ft. of the Bluestone Electric Traction Ry., at Bluefield, W. Va.; the bed of stone in this case varies from 10 to 15 ins. It has been laid also at the same place for 100 ft. on a rock-crusher siding of the Norfolk & Western Ry., where heavy engines and 50-ton cars are operated; in this case the bed of stone was 20 ins. deep. The depth of stone in any case must be sufficient to distribute the load over the entire surface of the roadbed.

A modified design for track carrying very fast and heavy traffic is shown in Fig. 2. The number of channel bar supports is increased, and the vertical anchors in the tie-bars are assisted by putting anchor plates across the ends of some of the channels, as shown.

The track system described above has been invented and patented by Mr. W. H. Coffman, of Bluefield, W. Va., to whom we are indebted for plans and other information.

Results of Trials of Steel and Concrete Ties.

The Tie Committee of the American Railway Engineering and Maintenance-of-Way Association last year appointed a sub-committee to collect information in regard to the use and life of metal and composite ties, and the report on this subject appears in the "Proceedings" of the association for 1909. Various designs in use were inspected personally, and the report (while far from complete in descriptive matter) gives some very interesting and authoritative information as to the results of actual service. We give below an abstract of the report, and have commented upon the matter in our editorial columns. It may be added that the sub-committee was composed of the following members: E. E. Hart (Chairman), Chief Engineer of the New York, Chicago & St. Louis Ry.; E. G. Ericson, Principal Assistant Engineer of the Northwest System of the Pennsylvania Lines; W. F. H. Finke, Tie and Timber Agent of the Southern Ry.

Steel Ties.

CARNEGIE TIE.*—There are approximately 1,200,000 steel ties of the Carnegie or I-beam type (Buhrer patent) in use in this country. As far as we have observed this tie it has fulfilled the requirements of a first-class tie, meeting the requirements fully as to gage, surface, level and alinement, where good ballast was in use.

Buffalo, Rochester & Pittsburg Ry.—Mr. E. F. Robinson, Chief Engineer, advises that they have 3,000 of the Carnegie steel ties in use; 1,500 in stone ballast at Colden, N. Y., and 1,500 in hard slag ballast at Ridgway, Pa. So far they have given good service. At first there was some trouble with the fastenings, when cinder ballast was used, but since this was replaced with slag the fastenings have not given any trouble. So far as could be determined by the committee, the steel tie gives a more solid and quiet track than the wooden tie, due to the rigid fastening of the rail to the tie. Apparently there is less vertical movement of track on the steel tie. The roadmaster stated that the cost of surfacing and lining was practically the same as for wood ties.

Bessemer & Lake Erie Ry.†—On a sharp curve east of Conneaut, O., laid with steel ties, the gage, alinement and level were good. The track men express a preference for the steel ties, claiming that the track is easier to maintain than with wood ties. At a point where three derailments had occurred, the wheels had merely bent down the upper flanges of the ties, and in no way reduced their usefulness. So far as the committee was able to learn, the steel ties and bolts give a stronger track than the wood ties and spikes. The bolts and clamps holding the rails were tight in most cases, and seemed to be holding the ties firmly to the rails.

Mr. Layng (Engineer of Track) claims that his men use very little more time in laying steel ties than they do in laying wood ties. They are used at switches. It seems to be the practice when a wood tie fails to replace it with a steel tie. The committee also saw that on curves steel ties had been sandwiched in for the purpose of holding track to gage, where ballast was poor and the tracks were sliding and spreading. It is claimed that by using the occasional steel ties this trouble can be stopped and good gage maintained until such a time as the old wooden ties can be replaced entirely with steel ties. Mr. Layng also stated that the cutting of slots or holes in the web of the tie had been abandoned, as it was found that with slag or stone ballast the holes (with web turned out as an anchor) were not necessary to keep the track from sliding sideways.*

A steel tie was taken out that had been in service four years. Very little rust was found on the web, and the bottom flange showed very little corrosion. The tie seemed to be smooth under the rail, and the wear at the rail seat could barely be felt when passing the hand over the tie. Bolts and clips showed very little wear. Providing the wear in future is no greater in proportion than it has been during four years, the tie will be good for 25 or 30 years. The committee observed the fastenings very closely, and reached the conclusion that first-class track can be maintained with the present form of Carnegie steel tie and fastening. The track foremen stated that when new track was laid the bolts holding the clips had to be tightened once or twice before they took a tight set, but that after the bolts were tight and nuts set they had no further trouble with the gage or fastenings.

New York Central Ry.—About a mile of main track near Castleton, N. Y., was laid with Carnegie steel ties in 1904. Early in 1907, this track was turned into a siding or freight track, and it is evident that since that time nothing has been done in the way of keeping it in line and surface or in keeping the bolts tight. No reliable information could be had as to the use and life of these ties. Very little loss of section by rust was in evidence.

Pittsburg & Lake Erie Ry.—Two types of the Carnegie steel tie are used, one with the regular clip fastening and the other with a clip and wedge.† During September, 1908, 3,000 of these ties were placed in the No. 3 low-speed freight track at McKees Rocks, Pa. These are of the regular type, with a clip and bolt fastening and a fiber plate under the rail for insulation. The electric circuits have been maintained with no special trouble. The track is in good gage, line and surface. The committee is advised that the track with steel ties is kept in surface and line with the same amount of labor as the track with wood ties.

Union Ry. (Pittsburg).—During the fall of 1908, 5,000 Carnegie steel ties with the wedge fastenings were put into the track.

Baltimore & Ohio Ry.—During November, 1906, these steel ties were laid for one mile on the old main line east of Marriottsville, Md. In June, 1908, oak ties were laid on another mile for comparison, and at that time both stretches of track were fully ballasted with stone. The traffic is down grade and extremely heavy. The alinement is about 62% curve; maximum curvature, 9° 30'; grade, 0.03%. The result so far is reported by the railway as in favor of the wooden ties.‡

SEITZ TIE.§—In October, 1904, 49 of these iron ties were put in main track at Emsworth, Pa., on the Pennsylvania Lines. In April, 1905, 13 were removed on account of being broken under the rail, and the rest were removed for the same reason in September, 1905.

HANSEN TIE.‖—In July, 1905, 500 of these ties were laid on the Pennsylvania Lines, near Emsworth, Pa. A great deal of trouble was experienced with the insulation, and with the ties sliding transversely and longitudinally in the stone ballast. The ties were in consequence removed from the main track in November, 1905, and placed in a passing siding, where they are still in service.

BOUGHTON TIE.¶—There were 18 of these placed on the Baltimore & Ohio Ry. near Akron, O. They are reported to have given good service.

SNYDER TIE.—These are laid in the Conemaugh yards and for about a mile at Derry, Pa., on the Pennsylvania Ry. None of them are in main track. The tie is a steel shell 3/16-in. thick, 8 ft. long, 7 ins. wide and deep, with the bottom open. The interior is filled with a mixture of asphalt and crushed stone. The fastenings are clips and bolts. So far the ties have given very satisfactory service.

BUHRER COMBINATION TIE.—In 1907, the Carnegie steel ties on the Lake Shore & Michigan Southern Ry. were removed from the high-speed track. They were

*This form of steel tie (which is the only one used to any extent in this country) was described in our issues of March 27, 1902, Aug. 24, 1905, and Dec. 24, 1908. While the report gives generally favorable accounts, we find some unfavorable results mentioned in the discussion of the report, some of which are noted below.—Ed.

Mr. Thompson (B. & O. Ry.).—A point I would like to bring out forcibly is the movement of the I-beam ties in the ballast. The ties skew around very badly and in a mile section the cost of maintenance was higher than for wood ties. There must be taken into consideration the additional quantity of ballast; this is a very important factor where stone ballast is used and where its cost is high. In a derailment, nearly all the ties included were either destroyed or so badly damaged that they had to be taken out.

Mr. Trimble (Pennsylvania Lines).—The trackmen complained continually about these ties moving in the ballast. The stone ballast was kept very well filled up, but not as full as it should have been. We would line the ties up square with the rail, and inside of a week they would be out of place and irregular. Finally the trackmen had so much trouble with them that they took them out, against the protest of the engineering department. On the whole we had a great deal of difficulty with this style of tie. Further, I think there will be very few railways willing to pay the price.

†The report omits the important fact that on this road the standard track construction includes the Carnegie steel ties, and that about 250,000 are in use. The fact that the road is owned by the "steel trust," of course, may be a reason for this, but the ties appear to give very satisfactory service.—Ed.

*As shown by a previous foot note this particular trouble from sliding in the ballast has been serious on other roads.—Ed.

†Engineering News, Dec. 24, 1908.

‡See statement in a previous footnote.—Ed.

§Rectangular trough section, with edges notched to let the rail rest on a block inside the trough. A photograph with the report shows cracks reaching from these notches nearly to the bottom of the tie.—Ed.

‖This is a dished plate ¼-in. to ⅜-in. thick, 14 ins. wide and 3 ins. deep at the middle, narrower and deeper at the ends, which are closed. Bolted clamp fastenings are used, with oval holes, and an inside washer plate at each hole is held by a single rivet.—Ed

¶This is a steel casting of rectangular box section, with metal ½-in. thick, 6 ins. wide on top, 8 ins. on bottom, 5 ins. deep. Clip fastenings are held by curved spikes engaging lugs in the tie.—Ed.

converted into combined wood and steel ties, which were laid in the freight track, east of Toledo. To care for the insulation, the top flange of the tie was cut off and two wooden blocks bolted to the web for spiking blocks and for the rail to rest on. These blocks rest on the bottom flange of the tie. The track was in good condition.

Concrete Ties.

BUHRER TIE.*—Lake Shore & Michigan Southern Ry.—About a mile of track was laid with this tie in 1904, on the Cedar Point Pier branch at Sandusky, O., including a 9° curve. The track is in first class condition as to surface, gage, level and line. The clips, bolts, etc., were tight and the track foreman stated that they gave him less trouble than the wood ties. There were no renewals up to September, 1908. The track is used for freight and excursion traffic. Heavy passenger engines use this track during the summer months. The track is ballasted with cinders.

Concrete ties and wood ties are mixed on the Sandusky Water-Works track. These have been in the track five years. Selected oak ties were laid at the same time the concrete ties were put in. At the present time fully one-third of the oak ties should be removed as they are badly decayed. The concrete ties are in first-class condition. Both were ballasted with cinders. On a Buhrer tie in the above track the top of the tie is very little, if any, rusted and the rail bearing shows scarcely any wear.† Under the clip a little more rust was found; concrete was in perfect condition and showed no signs of cracking.

Pennsylvania Lines.—About 600 of the Buhrer ties were used on the Northwest System during 1903 and 1904, in stone ballast. Nearly 500 of these ties were subjected to heavy and high-speed traffic, and the balance to medium traffic. The ties failed under traffic, the concrete breaking and crumbling from the reinforcement. The ties were removed from time to time, and by December, 1906, all had been removed on account of breaking.

Chicago Junction Ry.—This railway states that 19 Buhrer ties were put into the track in 1904, and that they were removed after a few months' service on account of breaking.

Lake Erie & Western Ry.—During August, 1903, 24 Buhrer ties were put into the track, in gravel ballast. Seven have been removed on account of breaking.

Chicago & Northwestern Ry.—In the north main track at Allis station, Milwaukee, 15 Buhrer ties were laid during August, 1902. They are reported to be still in service and apparently in good condition.

KIMBALL TIE.‡—During October, 1905, 63 of these ties were put into the southbound track of the Chicago & Alton Ry., near Lockport, Ill. The track was found to be in good condition, but several of the ties were cracked. Up to the present time they have given good service, holding the track to line and gage. Eight of these ties had been removed on account of being badly cracked. Of the remaining ties the committee found four ties with longitudinal cracks under the west rail. Under the east rail four were cracked longitudinally. The committee also found 15 ties were cracked crosswise under the west rail, and 17 under the east rail. To try and determine the cause of the cracked ties, the committee took out two ties and removed the spiking block from several more ties. In every case we found that the plug in the concrete had not been bored to receive the spike, and that in many cases the spike had partially or entirely missed the spiking plug, having been driven into the concrete. The failure of the ties at Lockport, in our opinion, is due partly to application. The New York, Chicago & St. Louis Ry. has six of these ties in the main track, and so far they have given good service.

*Engineering News, Aug. 17, 1905.

†An inverted rail is embedded in the top of the tie, with its base carrying the track rails.—Ed.

‡Engineering News, April 3 and Aug. 28, 1902. This tie has two concrete blocks or slabs connected by a pair of transverse steel channels; on each slab is a wooden cushion block for the rail, and in it are embedded plugs to receive the spikes.—Ed.

FIG. 1. CHENOWETH REINFORCED-CONCRETE TIES IN A YARD TRACK ON THE PENNSYLVANIA LINES (P., C., C. & ST. L. RY.) AT SCULLY, PA.

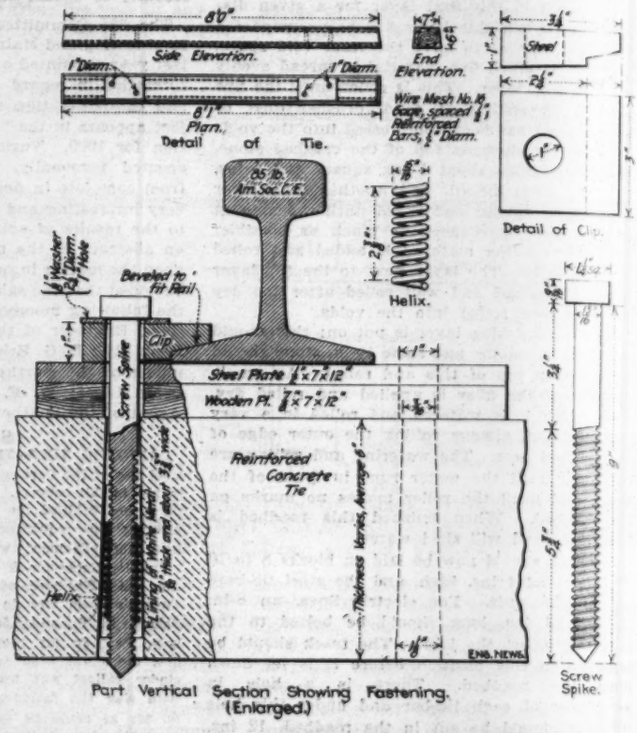

FIG. 3. THE CHENOWETH REINFORCED-CONCRETE TIE AND ITS RAIL FASTENINGS.

97 ties still in track, 12 are crushed under the rail, 9 cracked near the rail and 13 cracked near the center of the tie. [See later report quoted below.—Ed.]

KEEFER TIE.—The reinforcement consists of a number of steel rods. In December, 1905, 44 were placed in No. 5 track, Scully Yard, Pennsylvania Lines. They commenced to break shortly after being put in and were removed as fast as they broke, so that by June, 1906, all had been removed.

HICKEY TIE.—This is somewhat on the same lines as the Buhrer tie, the reinforcement consisting of an old rail; 19 were placed in track on the Michigan Central Ry. some years ago. The railway states that the ties were removed after two or three years' service on account of breaking.

ALFRED TIE.—About 100 of these ties were put in a freight track on the Pere Marquette Ry. in 1904. The railway reports that ten of these ties were removed in 1908 on account of being broken under the rail.

MISCELLANEOUS.—Other forms of reinforced-concrete ties have been tried, with similar results as with the Keefer ties.

FIG. 2. CHENOWETH REINFORCED-CONCRETE TIES REMOVED FROM TRACK, SHOWING CHARACTER OF FAILURE.

PERCIVAL TIE.*—Six of these were in use on the Pittsburg & Lake Erie Ry. for something less than two years. They were removed during the summer of 1908 on account of failure.

AFFLECK TIE.—This is a reinforced-concrete tie, 6 x 8 ins., the reinforcement consisting of a 3-in. I-beam. In October, 1904, 100 of these ties were placed in the main track near Emsworth, Pa., on the Pennsylvania

*Engineering News, Oct. 5, 1905. The view in the report shows the ties cracked and disintegrated.

Conclusions.*

Steel Ties.—Experiments with steel ties should be extended, and results carefully watched and reported.

Reinforced-Concrete Ties.—The committee concludes that no form of reinforced-concrete tie has been made which is suitable for heavy and high-speed traffic, but believes a properly reinforced-concrete tie, with proper fastenings, may be found economical in places where speed is slow and where conditions are specially adverse to the life of wood or metal ties.

[Since the abstract of the above committee report was prepared, we have received a copy of an official report as to the experience with the Chenoweth concrete ties on the Pennsylvania Lines, mentioned above. For this we are indebted to Mr. W. C. Cushing, M. Am. Soc. C. E., Chief Engineer of Maintenance of Way (Southwest System), and it is given below, practically in full. The ties in the track are shown in Fig. 1, while Fig. 2 shows the character of failure of some of the ties which were removed after about 2½ years' service.—Ed.]

The Chenoweth reinforced concrete cross ties in service at Scully Yard on the Pittsburgh Division of the Pennsylvania Lines were patented and manufactured by Alexander C. Chenoweth. These ties are 8 ft. long; the width on top is 7 ins. and on the bottom 8¼ ins.; they are 6 ins. thick. The concrete is built about a coil of No. 16 gage wire mesh, the coils ½-in. apart, and in addition, six reinforcing rods ½-in. diameter are used, three on the top and three on the bottom of the tie, near the surface. The rail rests on a wooden block ⅞ × 7 × 12 ins. on top of the tie and is secured in position by screw spikes and clips. The hole for the screw spike is 13/16-in. diameter at the top of the tie and 1¼ ins. at the bottom. A helical lining 2⅝ ins. long is used.

In October, November and December, 1906, 101 of these ties, costing $1.50 apiece, were installed in lead track No. 5 at Scully Yard. Part of the ties are on a 2° curve and part on a transition curve. The track is ballasted with cinders and the ties are spaced 18 to a 33-ft. rail; this is our standard spacing for main tracks, which is as close as will permit proper tamping. The rail is the 85-lb. Am. Soc. C. E. section and the condition of the line and surface maintained here is fair, probably better than the average track of its kind. Traffic over the ties is almost constant. The equipment moving over them is of the heaviest type, but the speed rarely exceeds eight miles an hour and will not average more than five miles an hour.

Early in 1907 it became evident that the wooden blocks under the rails would soon wear out as the rails soon cut through them. Consequently, flat steel tie-plates ½ × 7 × 12 ins. were applied on top of the wooden blocks in August, 1907. Before applying the tie-plates, however, all wooden blocks were renewed.

Before the ties had been in the track six months, it was observed that a number were crumbling under the rails. This occurred gradually at first, but when they had crumbled to such an extent as to cause the rail to pound under traffic, it progressed much more rapidly. Considerable difficulty has been experienced in holding the clips tight. The ordinary creeping of the rail has a tendency to turn them, and a number of them have been entirely unclamped in this way. It is necessary to go over all these clips about once a month and tighten them.

The number experimented with is too small to make any estimate of the relative cost of keeping up a track equipped with these ties as compared with that of keeping up a similar piece of track equipped with ordinary oak ties.

Prior to July 6, 1908, four ties were removed to allow the placing of two insulated joints. Two of these ties were in good condition, the other two had crumbled under the rail. Between July 6, 1908, and April 28, 1909, ten more ties were removed, none of these being joint ties. They had been left in service as long as safety would permit. All of them were badly crumbled under one rail, seven under the low rail and three under the high rail.

Of the 87 now in the track, 22 have crumbled under one rail or both rails; 6 show cracks under one rail which will probably result in crumbling in the near future; 18 that have neither crumbled nor cracked under the rail are cracked in the middle portion, 12 of these being well defined breaks and 6 merely surface cracks. The remainder (41) are apparently in good condition.

Of the 22 that have crumbled under the rails 7 have crumbled only under the high rail, 12 only under the low rail, and 3 under both rails. Four are joint ties; 9 are shoulder ties and 9 are intermediate ties.

Of the 99 ties tested, 20 were joint ties, 21 shoulder ties and 58 intermediate ties. Of the 41 good ties in the track, one is a joint tie, seven are shoulder ties and 33 are intermediate ties. These figures show that 95% of joint ties, 67% of shoulder ties and 43% of intermediate ties have either failed or shown signs of ultimate failure, but only 12% have been removed from the track. As trains never pass over this portion of track at speed greater than about 8 miles an hour, bad ties here and there are not dangerous. In a high-speed track it would be positively dangerous not to remove the majority of the 46 damaged ties.

*As adopted by the Association.

A Letter of Robert Fulton's on Canal Construction.

Nothing gives so vivid an idea of the personality of an individual long since passed away as reading one of his letters. At this time, when the centennial of Fulton's inauguration of steam navigation is being celebrated, it is of interest therefore to present a letter written by him and devoted to a subject with which his name will forever be connected. The letter was written to Albert Gallatin, Secretary of the United States Treasury, and probably in response to a request from the Secretary. It was published as an appendix to Gallatin's famous report on the construction of roads and canals, which was submitted to the United States Senate on April 4, 1808. The report was accompanied by a voluminous appendix containing letters and reports from various distinguished men interested in internal improvements. Among them was the letter from Fulton, which is reprinted, with some condensation, below. For the benefit of those of our readers who may wish to pursue the subject farther, we may state that the Gallatin report, with the Fulton letter attached, was reprinted in the Preliminary Report of the Inland Waterways Commission, issued last year (Senate Document No. 325, 60th Congress, First Session).

The reader must remember, in following Fulton's letter, that at the time it was written the railway as a means of transportation was wholly unknown, and his entire comparison, therefore, is based upon the common road, improved according to the turnpike method as then practiced.

Washington, Dec. 8, 1807.

Sir: By your letter of the 29th of July, I am happy to find that the attention of Congress is directing itself towards the opening of communications through the United States by means of roads and canals; and it would give me particular pleasure to aid you with useful information on such works, as I have long been contemplating their importance in many points of view.

But a year has not yet elapsed since I returned to America, and my private concerns have occupied so much of my time, that, as yet, I have acquired but very little local information on the several canals which have been commenced.

Such information, however, is, perhaps, at present, not the most important branch of the subject, particularly as it can be obtained in a few months at a small expense, whenever the public mind shall be impressed with a sense of the vast advantages of a general system of cheap conveyance. I hope, indeed, that every intelligent American will, in a few years, be fully convinced of the necessity of such works to promote the national wealth, and his individual interest. Such conviction must arise from that habit of reflection which accompanies the republican principle, and points out their true interest on subjects of political economy. From such reflections arises their love of agriculture, and the useful arts, knowing them to augment the riches and happiness of the nation; hence also their dislike to standing armies and military navies, as being the means of increasing the proportion of non-productive individuals whose labor is not only lost, but who must be supported out of the produce of the industrious inhabitants, and diminish their enjoyments.

Such right thinking does great honor to our nation, and leads forward to the highest possible state of civilization, by directing the powers of man from useless and destructive occupations to pursuits which multiply the productions of useful labor, and create abundance.

Though such principles actuate our citizens, they are not yet, in every instance, aware of their best interests; nor can it be expected that they should perceive, at once, the advantages of those plans of improvement which are still new in this country. Hence the most useful works have sometimes been opposed, and we are not without examples of men being elected into the State Legislatures for the express purpose of preventing roads, canals, and bridges being constructed. But in such errors of judgment our countrymen have not been singular. When a bill was brought into the British Parliament, fifty years ago, to establish turnpike roads throughout the kingdom, the inhabitants, for forty miles round London, petitioned against such roads; their arguments were, that good roads would enable the farmers of the interior country to bring their produce to the London market cheaper than they who lived nearer the city, and paid higher rents; that the market would be overstocked, the prices diminished, and they unable to pay their rents or obtain a living. The good sense of Parliament, however, prevailed, the roads were made, the population and commerce of London increased, the demand for produce increased, and he who lived nearest to London still had a superior advantage in the market.

In like manner I hope the good sense of our Legislature will prevail over the ignorance and prejudice which may still exist against canals. And here an important question occurs, which it may be proper to examine with some attention to this early stage of our public improvements, whether, as a system, we should prefer canals to turnpike roads. Our habits are in favor of roads; and few of us have conceived any better method of opening communications to the various parts of the states. But in China and Holland canals are more numerous than roads; in those countries the inhabitants are accustomed to see all their productions carried either on natural or artificial canals; and they would be as much at a loss to know how we, as a civilized people, could do without such means of conveyance as we are surprised at their perseverence and ingenuity in making them.* England, France, and the principal states of Europe, commenced their improvements with roads; but as the science of the engineer improved, and civilization advanced, canals were introduced, and England and France are now making every exertion to get the whole of their heavy productions water-borne; for they have become sensible of the vast superiority of canals over roads.

Our system, perhaps, ought to embrace them both; canals for the long carriage of the whole materials of agriculture and manufactures, and roads for traveling, and the more numerous communications of the country. With these two modes in contemplation, when public money is to be expended with a view to the greatest good, we should now consider which object is entitled to our first attention. Shall we begin with canals, which will carry the farmer's produce cheap to market, and return him merchandise at reduced prices? Or shall we first make roads to accommodate travelers, and let the produce of our mines and forests labor under such heavy expenses that they cannot come to market?

To throw some light on this interesting question, I will base my calculations on the Lancaster turnpike road. There the fair experiment has been made to penetrate from Philadelphia to the interior country; and the mode of calculation here given will serve for drawing comparisons on the utility of roads and canals for all the great leading communications of America.

From Philadelphia to the Susquehanna, at Columbia, is 74 miles; that road, if I am rightly informed, cost, on an average, $6,000 a mile, or $444,000 for the whole. On it, from Columbia to Philadelphia, a barrel of flour, say 200 weight, pays $1 carriage. A broad wheel wagon carries 30 bbls., or 3 tons, and pays for turnpike $3; thus for, each ton carried, the turnpike company receives only $1.

I will now suppose a canal to have been cut from Philadelphia to Columbia, and, with its windings, to make 100 miles, at $15,000† a mile; or, for the whole, $1,500,000. On such canal, one man, one boy, and horse would convey 25 tons 20 miles a day,‡ on which the following would be the expenses:

One man	$1.00
One horse	1.00
One boy	.50
Tolls for repairing the canal	1.00
Tolls for passing locks, inclined planes, tunnels, and aqueducts	1.00
Interest on the wear of the boat	.50
Total	$5.00

This is equal to 20 cts. a ton for 20 miles, and no more than $1 a ton for 100 miles, instead of $10 paid by the road. Consequently, for each ton carried from Columbia to Philadelphia on the canal, the company might take a toll of $6 instead of one which is now got by the road; and then the flour would arrive at Philadelphia for $7 a ton instead of $10, which it now pays. The merchandise would also arrive at Columbia, from Philadelphia, for $3 a ton less than is now paid, which cheap carriage, both ways, would not only benefit the farmer and merchant, but would draw more commerce on the canal than now moves on the road, and hereby add to the profits of the company.

But to proceed with my calculation. I will suppose that exactly the same number of tons would move on the canal that are now transported by the road. Again, let it be supposed that, at $1 a ton, the turnpike company gains 5% per annum on their capital of $444,000 or $22,900, consequently, 22,200 tons must be carried, which, at $6 a ton to the canal company, would have given $133,300 a year, or 8½% for their capital of $1,500,000.

*The royal canal from Canton to Pekin is 825 miles long; its breadth, 50 ft.; its depth, 9 ft.

†On averaging the canals of America, $15,000 a mile will be abundantly sufficient to construct them in the best manner, particularly if made on the inclined plane principle with small boats, each carrying 6 tons.

‡One horse will draw on a canal from 25 to 50 tons, 20 miles in one day. I have stated the least they ever do, and the highest rate of charges, that no deception may enter into their calculations.

The reason of this vast difference in the expense of carriage by roads or canals, will be obvious to any one who will take the trouble to reflect that, on a road of the best kind, four horses, and sometimes five, are necessary to transport only three tons. On a canal one horse will draw 25 tons, and thus perform the work of 40 horses. The saving, therefore, is in the value of the horses, their feeding, shoeing, gear, wagons, and attendance. These facts should induce companies to consider well their interests, when contemplating an enterprise of this sort, and what would be their profits, not only in interest for their capital, but the benefit which their lands would receive by the cheap carriage of manure, and of their productions.

In considering the profit to accrue to a company from a canal instead of roads, there is another important calculation to be made; and for that purpose I will proceed with the Lancaster turnpike, supposing it to extend to Pittsburg, 320 miles, on which, the carriage being at the rate now paid from Columbia to Philadelphia, that is, $10 a ton for 74 miles, the ton from Pittsburg would amount to $42; at which price, a barrel of flour would cost $4 in carriage, an expense which excludes it from the market. Thus, grain, the most important and abundant production of our interior country, and which should give vigor to our manufactures, is shut up in the districts most favorable to its culture; or, to render it portable, and convert it into cash, it must be distilled, to brutalize and poison society. In like manner, all heavy articles of little moneyed value can only move within the narrow limits of 100 miles; but were a canal made the whole distance, and by one or more companies, they might arrange the tolls in the following manner, so as to favor the long carriage of heavy articles.

The expense of man, boy, and horse, as before stated, would cost only $3 to boat one ton of flour 300 miles; this is 30 cts. a bbl. Suppose, then, that the company received 70 cts. a bbl., or $7 a ton, flour could then come from Pittsburg to Philadelphia for $1 a barrel, the sum which is now paid from Columbia. Thus, the canal company would gain $7 a ton by a trade which could never move through a road of equal length. Here we see that on canals the tolls may be so arranged as to draw to them articles of little moneyed value; and it would be the interest of the company or companies to make such regulations. But on turnpike roads no such accommodation of charges, in proportion to distance, can be effected, because of the number of horses, which cannot be dispensed with.* Even were the roads made at the public expense, and toll free, still the carriage of one ton for 300 miles would cost at least $35. But were canals made at the public expense, and no other toll demanded than should be sufficient to keep them in repair, a ton in boating and tolls would only cost $3 for 300 miles; and for $35, the sum which must be paid to carry one ton 300 miles on the best of roads, it could be boated 3,500 miles, and draw resources from the center of this vast continent.

But, striking as this comparison is, I will still extend it. The merchandise which can bear the expense of carriage on our present roads to Pittsburg, Kentucky, Tennessee, or any other distance of 300 miles, and which for that distance pays $100 a ton, could be boated on canals 10,000 miles for that sum.

As these calculations are founded on facts which will not be denied by any one acquainted with the advantages of canals, it is the interest of every man of landed property, and particularly of the farmers of the back countries, that canals should be immediately constructed, and rendered as numerous as the funds of the nation will permit, and the present population requires; and, as inhabitants multiply most towards the interior, and must extend westward, still moving more distant from the seacoast and the market for their produce, it is good policy and right that canals should follow them. In 25 years our population will amount to 14,000,000, two-thirds of whom will spread over the Western countries. Suppose, then, that $3,500,000 were annually appropriated to canals; such a sum would pay for 300 miles of canals each year; and in 20 years we should have 6,000 miles circulating through, and penetrating into the interior of the different states. Such sums, though seemingly large, and such works, though apparently stupendous, are not more than sufficient to keep pace with the rapid increase of our population, to open a market, and carry to every district such foreign articles as we near the coast enjoy. With this view of the subject arises a political question of the utmost magnitude to these states, which is, that, as our national debt diminishes, and the treasury increases in surplus revenue, will it not be the best interests of the people to continue the present duties on imports, and expend the products in national improvements?

There is another great advantage to individuals and the nation arising from canals, which roads can never give. It is that when a canal runs through a long line of mountainous country, such as the greater part of the interior of America, all the grounds below for half a mile or more may be watered and converted into meadows, and other profitable culture. How much these conveniences of irrigation will add to the produce of agriculture, and the beauties of nature, I leave to experienced farmers and agricultural societies to calculate. In Italy and Spain it is the practice to sell water out of the canals for watering meadows and other lands. In such cases tubes are put into the canal, under the pressure of a certain head of water, and suffered to run a given time for a fixed price; the moneys thus gained add much to the emoluments of the canal companies.

But, with all these immense advantages, which canals give, it may be a question with many individuals, whether they can be constructed in great leading lines from our seacoasts and navigable rivers, to the frontiers of the several states, or pass our mountains, and penetrate to the remote parts of our interior country. Should doubts arise on this part of the plan, I beg leave to assure you that there is no difficulty in carrying canals over our highest mountains, and even where nature has denied us water; for water is always to be found in the valleys, and the canal can be constructed to the foot of the mountain, carrying the water to that situation. Should there be no water on the mountain, or its sides, there will be wood or coals; either, or both of which, can be brought cheap to the works, by means of the canal. Then with steam engines, the upper ponds of canal can be filled from the lower levels, and, with the engines, the boats can, on inclined planes, be drawn from the lower to the upper canal; for this mode of operating it is necessary to have small boats of six tons each. As the steam engines are to draw up and let down the boats on inclined planes, no water is drawn from the upper level of canal, as when locks are used; consequently when the upper ponds have been once filled, it is only necessary that the engine should supply leakage and evaporation. There is another mode of supplying the leakage and evaporation of the higher levels; on the tops and sides of mountains there are hollows or ravines, which can be banked at the lower extremity, thus forming a reservoir to catch the rain or melted snow. From such reservoirs, the ponds of canal can be replenished in the dry months of summer. This mode of reserving water is in practice in England for canals, and in Spain for irrigation.

Having thus, in some degree, considered the advantages which canals will produce in point of wealth to individuals, and the nation, I will now consider their importance to the Union, and their political consequences.

1. Their effect on raising the value of the public lands, and thereby augmenting the revenue.

In all cases where canals shall pass through the lands of the United States, and open a cheap communication to a good market, such lands will rise in value for 20 miles on each side of the canal. The farmer who will reside 20 miles from the canal, can, in one day, carry a load of produce to its borders; and were the lands 600 miles from one of our seaport towns, his barrel of flour, in weight 200 lbs. could be carried that distance for 60 cts., the price which is now paid to carry a barrel 50 miles on the Lancaster turnpike. Consequently, as relates to cheapness of carriage, and easy access to market, the new lands which lie 600 miles from the seaports, would be of equal value with lands of equal fertility, which are 50 miles from the seaports. But, not to insist on their being of so great a value until population is as great, it is evident that they must rise in value in a three or four-fold degree; every lineal mile of canal would accommodate 25,600 acres; the lands sold by the United States in 1806, averaged about $2 an acre; and certainly every acre accommodated with a canal, would produce $6; thus, only 20 miles of canal, each year, running through national lands, would raise the value of 512,000 acres at least $4 an acre, giving $2,000,-043 to the Treasury, a sum sufficient to make 136 miles of canal. Had an individual such a property, and funds to construct canals to its center, he certainly would do it for his own interest. The nation has the property, and the nation possesses ample funds for such undertakings.

2. On their effect in cementing the Union, and extending the principles of confederated Republican Government, numerous have been the speculations on the duration of our Union, and intrigues have been practised to sever the Western from the Eastern States. The opinion endeavored to be inculcated was, that the inhabitants behind the mountains were cut off from the market of the Atlantic States; that, consequently, they had a separate interest, and should use their resources to open a communication to a market of their own; that, remote from the seat of Government, they could not enjoy their portion of advantages arising from the Union, and that, sooner or later, they must separate and govern for themselves.

Others, by drawing their examples from European Governments, and the monarchies which have grown out of the feudal habits of nations of warriors, whose minds were bent to the absolute power of the few, and the servile obedience of the many, have conceived these states of too great an extent to continue united under a republican form of Government, and that the time is not distant when they will divide into little kingdoms, retrogading from common sense to ignorance, adopting all the follies and barbarities which are every day practised in the kingdoms and petty states of Europe. But those who have reasoned in this way have not reflected, that men are the creatures of habit, and that their habits as well as their interests may be so combined, as to make it impossible to separate them without falling back into a state of barbarism. Although in ancient times some specks of civilization have been effaced, by hoards of uncultivated men, yet, it is remarkable that since the invention of printing, and general diffusion of knowledge, no nation has retrogaded in science or improvements; nor is it reasonable to suppose that the Americans, who have as much if not more information in general than any other people, will ever abandon an advantage which they have once gained. England, which at one time, was seven petty kingdoms, has, by habit, long been united into one. Scotland, by succession, became united to England, and is now bound to her by habit, by turnpike roads, canals, and reciprocal interests. In like manner all the counties of England, or departments of France, are bound to each other; and when the United States shall be bound together by canals, by cheap and easy access to market in all directions, by a sense of mutual interests arising from mutual intercourse and mingled commerce, it will be no more possible to split them into independent and separate Governments, each lining its frontiers with fortifications and troops, to shackle their own exports and imports to and from the neighboring states, than it is now possible for the Government of England to divide and form again into seven kingdoms.

But it is necessary to bind the states together by the people's interest, one of which is to enable every man to sell the produce of his labor at the best market, and purchase at the cheapest. This accords with the idea of Hume, "that the government of a wise people would be little more than a system of civil police; for the best interests of man is industry, and a free exchange of the produce of his labor for the things which he may require."

On this humane principle, what stronger bonds of union can be invented, than those which enable each individual to transport the produce of his industry 1,200 miles for 60 cts. the hundred weight? Here, then, is a certain method of securing the Union of the States, and of rendering it as lasting as the continent we inhabit.

It is now eleven years that I have had this plan in contemplation for the good of our country. At the conclusion of my work on small canals, there is a letter to Thomas Mifflin, then Governor of the State of Pennsylvania, on a system of canals for America. In it I contemplated the time when "canals should pass through every vale, wind around each hill, and bind the whole country together in the bonds of social intercourse"; and I am happy to find that, through the good management of a wise administration, a period has arrived when an overflowing treasury exhibits abundant resources, and points the mind to works of such immense importance. Hoping speedily to see them become favorite objects with the whole American people,

I have the honor to be your most obedient servant,

Robt. Fulton.

to Albert Gallatin, Esq., Secretary of the Treasury.

*In my work on small canals, published in 1796, page 140, there is a table showing a mode of regulating the boating and tonnage in such manner that a ton may be transported 1,300 miles for $5; yet by this method canal companies would gain more toll than by any other means yet practised.

AN EXPLOSION OF DYNAMITE in the Petguina mine at Guanajuato, Mexico, Sept. 22, caused the death of six men, one of whom, reports state, was John M. Grice, M. Am. Inst. M. E.

A POWDER-MILL EXPLOSION Sept. 25 at Edwards station, twelve miles west of Peoria, Ill., killed one man and seriously injured another. The accident occurred at the Buckeye Powder Mill.

AN ELECTRIC STORM, in the United States and Europe, seriously interrupted the land telegraph and cable systems generally on Sept. 26. There was no special electrical display in the skies but the presence of the remarkably heavy currents, in the upper layers of the earth's surface, is variously attributed to the aurora and to disturbances in the sun. These "earth currents" so traveled on the wires of grounded circuits as to render impossible the transmission of intelligence. The trouble existed all the evening.

THE DIRIGIBLE BALLOON "REPUBLIQUE," of the French army, was destroyed near Paris on Sept. 25 and in falling crushed all four officers who were in the car, Capt. Marchal, Lieuts. Phaure, Vincenot and Reux. The reports of the accident are somewhat conflicting, but it is generally believed that a propeller blade broke and a flying piece ripped open the gas bag. Gas is presumed to have escaped from the rent, ignited from the internal-combustion engine and caused the main body

of gas to explode. The balloon was proceeding at a height of slightly over 300 ft. at the time.

Capt. Ferber, also of the French army, was killed, near Paris while making experimental flights with an aeroplane flyer on Sept. 22.

TWO DAM FAILURES, or partial failures, were reported in the newspapers early in September. The dams were located in the Zuni Mountains in New Mexico, one built by the Bluewater Development Co., of Albuquerque, an irrigation enterprise, and the other what is known as the Black Rock Dam, which was built jointly by the Bureau of Indian Affairs, of the Interior Department, and the U. S. Reclamation Service. The failure of the Bluewater dam is described on another page of this issue, but as yet detailed reports as to the Government dam are not available. According to the best information the dam itself is intact, although the heavy flow of water over the spillway caused some erosion and settlement at that point.

AN EXPLOSION of photographic films at Pittsburg, Pa., Sept. 27, wrecked the Ferguson Building, an eight-story structure in which were the offices of the Columbia Film Exchange. About 50 persons were injured. An employee of the film exchange states, according to reports, that he entered the vault in which films were kept and that one of the films became ignited when he switched on the electric light. The films were of the sort used in moving-picture machines. He closed the door of the vault and ran from the building, followed by the other employees of the film company. Before they had reached the street, an explosion occurred which wrecked the south wall of the building and a number of interior partitions and so damaged the remaining walls that the building will have to be razed. Many of the persons injured were hurt in the stampede from the building of its hundreds of occupants.

THE CABOOSE OF A STOCK TRAIN of the Chicago, Milwaukee & St. Paul Ry. was crushed Sept. 28 at Chicago, Ill., by the locomotive of a following passenger train on the Pennsylvania R. R. Six men sleeping in the caboose were killed and ten others were seriously injured. No one on the passenger train was hurt. The accident occurred shortly after midnight. The passenger train had just rounded a curve at high speed when the engineer saw the stock train a short distance ahead. He set the emergency brakes and jumped, followed by the fireman. Four cars of the stock train were wrecked.

A handcar was struck by a freight train on the Chicago & Northwestern Ry. Sept. 26 near Edgar, Wis. Four of the nine persons on the handcar were killed and three others badly injured.

THE GULF HURRICANE of Sept. 20, according to reports of Sept. 26, caused the death of more than 200 persons in Louisiana. Most of the dead were found in the lowlands in the southern part of the state.

TWO EXPRESS TRAINS on the Boston & Maine R. R. collided near Pattee, N. H., Sept. 21. Three men were killed, none of whom was a passenger. The two trains were running in the same direction and left Pattee station within a few minutes of each other. Shortly after leaving the station, the locomotive of the Quebec express (No. 4) gave trouble of a sort which necessitated a slowing down. Before a flagman could get back to warn the train behind, the Montreal train (No. 6) crashed into the rear of the Quebec train. A dense fog diminished the chances of averting the accident. The rear sleeper of the train ahead was partially telescoped by the locomotive of the other.

A FIVE-STORY FRAME BUILDING COLLAPSED at Lowell, Mass., Sept. 14. Three of the twelve workmen in the building were injured. A fire started in the ruins and extensively damaged the building's contents. The building was owned by the American Hide & Leather Co. and was used as a storage warehouse. It was 100 by 150 ft. in plan and was erected about 20 years ago.

THE DETROIT RIVER TUNNEL had its last section sunk into place on Sept. 14. It is expected to be ready for traffic by Jan. 1.

PRIZES FOR SUPERIOR TRACK MAINTENANCE to the total amount of $5,400 were awarded on Sept. 21 to various track supervisors and assistants on the Pennsylvania R. R. These prizes are awarded each year to the head of those sections of the road which, after frequent inspection by the higher maintenance officers, are decided to be in the best condition for easy riding. This year the first prize, $800 to the Supervisor and $400 to the Assistant Supervisor, went to the division from Woodbine Ave., West Philadelphia, to a point west of Coatesville, Pa. The remaining prizes were four of $800 each, $600 of which went to the Supervisor and $200 to his assistant and a $1,000 prize, divided into $700 and $300, as above, to that section showing the greatest improvement during the year.

THE GOOD ROADS CONVENTION at Cleveland, Ohio, last week brought forward among its main sentiments, according to the Cleveland "Leader," the following:

Control by the state highway commissioner of all expenditure of state aid funds in road improvement, adoption of a definite policy of trunk line roads, greater cooperation between the states, a uniform system of road improvement, and a reduction in the cost of road work to make it appeal to the farmer. The sentiment was emphatic that until road construction could be brought within a cost limit of $2,000 a mile the average farmer would not become an enthusiastic good roads advocate.

Mr. Charles P. Light, Highway Commissioner of West Virginia, reported that the sample roads built in several parts of West Virginia by the U. S. Government, at a cost of $10,000 a mile, did not last five years, and that in consequence the sentiment of the people of the state had been influenced against the construction of macadamized roads.

SLIDES ON THE BREAKWATER at the Pacific end of the Panama Canal.—The slide on the breakwater from Balboa along the Pacific entrance to the Canal to Naos Island, a distance of three miles, continues. The point at which the greatest difficulty is experienced in getting the embankment to stand is across the channel through which vessels formerly sailed up to the Balboa wharf. This channel was kept open by dredging for several years, and was filled only six months ago when the new channel was opened to navigation. Rock and earth have been dumped into it, and the embankment has been brought to grade several times, but each time has sunk, carrying with it the trestle on which the dump trains run. A new trestle has been driven after every sinking and more material has been dumped in, and this process will be continued until the embankment stands at the grade desired.

The bottom of the French channel is much like the land on which the construction of the old Sosa dam was begun, and like the latter, gives way when a weight heavier than itself is imposed upon it. It will continue to give way until the material being dumped there either rests on solid bottom or spreads out over a sufficient area, and then the sliding will cease and the breakwater will become as stable as the toe of the old Sosa dam, over which heavy trains have been running daily for two years without any settlement occurring.

Although the embankment to Naos Island is serving the useful purpose of keeping cross currents out of the new channel, and will be of other utility when the island is connected with the mainland, its primary purpose was that of a dump for spoil from Culebra Cut, and it is serving this well.

If it were desired to complete the breakwater in the next few months the slide might be regarded as serious, but there is ample time and material. The breakwater will reach Naos Island long before the excavation in the south end of Culebra Cut is finished. The Central Division will probably continue to use it as a dump, however, merely broadening out the present narrow embankment.—"Canal Record," Sept. 15.

STREET RAILWAY ACCIDENTS on the lines of the Philadelphia Rapid Transit Co. killed 47 persons during the first eight months of the year 1909 up to and including Aug. 22. This is roughly about one-fifth the average number of fatalities from the same cause in New York City in an equal length of time. Twenty-three of the 47 killed in Philadelphia were children under twelve years old.

NO FATALITIES TO PASSENGERS in the year 1908 is the record of four large railway systems in the United States: the Pennsylvania, Chicago, Burlington & Quincy, Chicago & Northwestern and the Atchison, Topeka & Santa Fe. In the same year, no passengers were killed on the railways of the United Kingdom.

ACCIDENTS IN KENTUCKY COAL MINES in the year 1908, according to the report of E. W. Parker, of the U. S. Geological Survey, caused 39 deaths. Of these, 17 are ascribed to falls of rock and 12 to explosions. The total number of employees was 16,996, so that the death rate per thousand employees was 2.3. The number of tons of coal mined for each life lost was 262,732. Of the total production of 10,246,553 short tons, 51.27% was mined by machines.

MINING ACCIDENTS in the Transvaal in the month of July, 1909, caused the deaths of 79 men and the injury of 100 others.

THE GUNNISON IRRIGATION SYSTEM in Colorado, centering about the 6-mile Gunnison Tunnel, was formally opened by President Taft on Sept. 23. The tunnel conducts water from the Grand Canyon of the Gunnison River southwestward under Vernal Mesa into the valley of the Uncompahgre River, a stream of much smaller drainage area. This tunnel was completed during the past summer, after four years of construction. It has rectangular cross-section, 10½ × 11½ ft., and is lined with concrete. A new American speed record for rock heading progress was set during the work, though this was later surpassed by the Los Angeles Aqueduct tunneling. The distributing system at the west of the tunnel is not yet fully built.

SPECIAL HYDRAULIC STOP VALVES for the forced-feed lubricating system serving the step bearings of Curtis turbines have recently been installed in one of the plants of the New York Edison Co. The pressure in the lubricating system is 1,500 lbs. per sq. in. To withstand this pressure, the valves have extra heavy steel bodies and are packed with a special packing which is said to retain its elasticity without softening under the action of the oil. In this type of valve, to relieve the pressure on the under side of the valve, the valve stem is extended downward and carries at its lower end a piston working in a cylinder formed in the valve body. In the ordinary form, this cylinder is open to the air at its lower end and blowouts of the piston packing are very annoying.

An improved construction has been adopted for the new valves. A pressure-tight chamber is provided below the piston on the lower end of the valve stem. There is a pet cock in the bottom of this chamber which is left open when running under ordinary conditions to act as a tell-tale if the packing starts a leak. In case of a leak, the pet-cock is closed and the valve may then be continued in use until such time as a repair can be conveniently made. These valves and the extra heavy steel check valves used in the lubricating system have seats of a special metal which are spun into place in the steel bodies. The valves were made by the Watson-Stillman Co., of New York City.

CALIFORNIA PETROLEUM.—Advance notices of a bulletin by Mr. L. E. Aubury, of San Francisco, State Mineralogist, shows that the state produced 48,306,910 bbls. of petroleum in 1908. This was valued at $26,506,181, or more than the estimated gold production for the same time. The production in the principal oil counties is given as follows:

County.	Bbls.	Value.
Kern	18,777,871	$9,388,935
Fresno	10,725,389	5,898,964
Santa Barbara	8,847,589	4,423,794
Los Angeles	6,244,347	4,062,052
Orange	3,376,089	2,532,517
Ventura	289,625	217,219
Santa Clara	35,400	17,700
San Luis Obispo	10,000	5,000

In ten years the annual output of California petroleum has increased practically twenty fold. The State Mineralogist's figures are as follows:

Year.	Bbls.
1887	678,572
1888	690,333
1889	503,220
1890	307,360
1891	323,600
1892	385,049
1893	470,179
1894	783,078
1895	1,245,339
1896	1,257,780
1897	1,911,569
1898	2,240,088
1899	2,677,875
1900	4,329,950
1901	7,710,315
1902	14,356,910
1903	24,340,839
1904	29,736,003
1905	34,273,701
1906	32,624,000
1907	40,311,171
1908	48,306,910

SURVEYS FOR A STORAGE RESERVOIR for river regulation are being made under direction of the Corps of Engineers, U. S. A., on the Etowah River, near Cartersville, Ga. The work is being done in accordance with a clause in the last River and Harbor Bill, which directed that

examination for the improvement of the navigation of the river should include investigations necessary to determine whether storage reservoirs at the headwaters can be utilized to advantage, and if so what portion of their cost should be borne by owners of water-power and others.

According to press reports, the reservoir now under examination would require a dam 160 ft. high and would store about 135,000,000 cu. ft. of water. It is not known, of course, whether the engineers in charge of the work will recommend construction of the reservoir, but it is noteworthy that this is the first time that actual surveys for such reservoirs have been made under direction of the Corps of Engineers.

AN EXPERIMENTAL FARM has been undertaken by the Pennsylvania R. R. Co. at Bacon, Del., under direction of Mr. H. S. Lippincott, a graduate of the Cornell Agricultural College. The farm is located in a region celebrated for its fruit production and market gardens, yet a large proportion of the land is still uncultivated. It is intended to demonstrate upon this farm the possibilities in producing choice varieties of fruits and vegetables not now raised, and also the possibility of restoring "worn-out" lands to fertility.

INDUSTRIAL-WORKS ACCIDENTS in this country during July and August, according to data collected by the Fidelity and Casualty Co., of New York City, were approximately as follows:

	July.	August.
Boiler	19	7
Steam Pipe	4	2
Fly Wheel	6	3
Elevator	44	34

Figures collected by the "Scientific American" show the boiler explosions of the country for recent years as follows:

	Explosions.	Persons killed.
1905	450	383
1906	431	235
1907	471	300
1908	470	281
*Oct., 1867, to Jan., 1900	10,051	10,884

(*15,634 injured also.)

Boiler explosions in England for the year are reported by the Board of Trade as 73. In 36 of these 23 persons were killed and 50 were injured. The number of explosions is stated to be slightly above the annual average but the loss of life is less.

MAY SEWAGE BE DISCHARGED into the New York barge canal? The cities along its route have for many years been discharging sewage into the old Erie canal and into the Mohawk and other rivers which are to be slack watered in the construction of the barge canal. The damming of the river, however, will make its pollution by sewage much more objectionable. Public opinion in New York, moreover, is very sensitive just now on the matter of stream pollution by sewage, hence it seems quite likely that sewage may be excluded from the barge canal. If this is done some extensive sewage disposal works will have to be undertaken at an early date by some of the cities in central New York.

VACCINATION FOR TYPHOID, now being tested in the U. S. army, is said to show promising results so far, although no official statement regarding it is yet forthcoming. The Washington correspondent of the St. Louis "Republic" recently reported that out of 1,000 soldiers who have been vaccinated, and many of whom have been in close contact with typhoid patients, not a single one has contracted the disease. The vaccination appears to give no serious results, as only 8% of those vaccinated were incapacitated for duty, and of those excused none were off duty longer than 48 hours.

Personals.

Mr. John C. Baxter has resigned his position as Chief Locating Engineer of the Chicago, Milwaukee & Puget Sound Ry., to enter the service of the Oregon Trunk Line.

Mr. A. W. Lewin, Assoc. Am. Inst. E. E., has been made Manager of the New Orleans office of the Sprague Electric Co., with which he has been connected for some time.

Mr. T. F. Sharp has been appointed Assistant Superintendent of the Victoria division of the Galveston, Harrisburg & San Antonio Ry., to succeed Mr. E. J. Nichols, resigned.

Mr. C. M. Hoffman, Master Mechanic of the St. Louis-Louisville lines of the Southern Ry., at Princeton, Ind., has resigned, effective Oct. 1, to take a position with another railway.

Mr. C. J. Cooper, Master Mechanic of the Toledo & Ohio Central Ry. has resigned and will sail for Japan to become American Mechanical Instructor in the Kumamota Higher College of Technology.

Mr. W. H. Guild, Secretary to the Vice-President and General Manager of the Oregon Railroad & Navigation Co., has been appointed an assistant superintendent of the Oregon division, with headquarters at Portland, Ore.

Mr. P. C. Kuegle has resigned his position as Chief Inspector with the Youngstown Sheet & Tube Co. and will sail from New York Oct. 9 for India to become Chief Inspector of construction and General Yard Master for the Tata Iron & Steel Co.

Mr. C. W. Saxman, M. Am. Inst. Min. Eng., formerly General Manager of the Tintic Mining & Development Co. and the Yampa Smelting Co., has gone into business as a consulting mining engineer, and has opened an office at 312 Dooly Building, Salt Lake City, Utah.

Mr. Geo. F. Cotter, General Superintendent of the Ft. Worth & Denver City Ry., has resigned and will be associated with the National Lumber Co. at Texarkana, Tex. He will be succeeded Oct. 1 by Mr. H. A. Gausewitz, at present Division Superintendent at Childress, Tex.

Mr. A. A. Tisdale, Assistant to the Vice-President and General Manager of the Grand Trunk Pacific Ry., has been appointed Superintendent of the Lake Superior division, with headquarters at Fort William, Ont. Mr. Tisdale entered the service of the Grand Trunk Ry. in the local freight offices at Hamilton, Ont., about 15 years ago.

Mr. Howard E. Boardman, Assoc. M. Am. Soc. C. E., formerly senior Assistant Engineer of Construction on the North River tunnels of the Pennsylvania Tunnel & Terminal R. R., has become Assistant Engineer in the maintenance-of-way department of the Missouri Pacific Ry. at St. Louis, Mo.

Mr. David L. Bush, General Superintendent of the Chicago, Milwaukee & St. Paul Ry., has been appointed General Manager to succeed Mr. W. J. Underwood, resigned. Mr. Bush will be succeeded as General Superintendent by Mr. H. B. Earling, who remains also General Superintendent of the Chicago, Milwaukee & Puget Sound Ry. The headquarters of both Mr. Bush and Mr. Earling will be at Chicago, Ill.

Mr. W. G. Bierd, General Superintendent of the New York, New Haven & Hartford R. R., has resigned that position to take up a similar one with one of the central western railways controlled by Mr. James J. Hill. He will be succeeded Oct. 1 by Mr. Benjamin R. Pollock, at present Division Superintendent at Hartford, Conn. Mr. Pollock will be succeeded by Mr. A. W. Honywill, Assistant Superintendent of the same division.

Mr. W. E. Wickenden has been appointed Assistant Professor of electrical engineering at the Massachusetts Institute of Technology to assume the duties vacated by Mr. George C. Shaad who has gone to the University of Kansas to take charge of the department of electrical engineering at that place. Mr. Wickenden is a graduate of Dennison University, taught a year in Rochester, New York, and followed that by a year of graduate study of physics at the University of Wisconsin. He is now in the electrical engineering staff of the University of Wisconsin, and is the author of a book, now on the press, on photometry and illumination.

Obituary.

James J. Hagerman, formerly President of the Colorado Midland Ry. and the Pecos Valley & Northwestern Ry., died Sept. 14 at Milan, Italy. Mr. Hagerman was born at Port Hope, Canada, in 1838, and was a graduate of the University of Michigan in the class of 1861. He was President of the Colorado Midland in 1887-'88 and first became associated with the Pecos Valley Ry. (afterward the Pecos Valley & Northeastern) in 1890.

Robert Hoe, the inventor of numerous improvements in printing presses, died Sept. 22 at London, England, where he had gone from his home in New York City for his annual business visit. Mr. Hoe was born in New York City in 1839. He entered the printing-press factory founded by his grandfather and developed the Hoe cylinder, patented by his uncle, Richard M. Hoe, in 1846, into the modern printing machine. One of his more recent inventions was an improved form of press for printing in colors which has since come into general use. Mr. Hoe was the author of several books on printing, including a history of its development from the time of Gutenberg to the present, and was the owner of a valuable library of rare books which he had collected. At the time of his death he was the principal owner of the firm of R. Hoe & Co., with factories in New York and London. His body has been embalmed and is to be brought to New York for burial.

Engineering Societies.

COMING MEETINGS.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 29-30. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock, Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 15, 19. Annual meeting, at Cincinnati, Ohio. Secy., Clinton R. Woodruff, Philadelphia, Pa.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C. Secy., Martin S. Decker, Albany, N. Y.

AMERICAN RAILWAY ASSOCIATION.
Nov. 17. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 18-19. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 1-3. Annual convention at Milwaukee, Wis. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN PEAT SOCIETY.—The third annual meeting was held at the Massachusetts Institute of Technology, Boston, Mass., Sept. 23-25.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.—The annual convention will be held in Denver, Colo., Oct. 7-9. The secretary is Mr. J. C. Lawler, P. O. Box 938, Colorado Springs, Colo.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.—To succeed Mr. J. C. Van Doorn, of Minneapolis, resigned, Mr. A. E. Pfiffner, of St. Paul, Minn., has been elected secretary. Mr. Pfiffner has been engaged in the manufacture of cement machinery for five years and, in partnership with his father, organized the St. Paul Cement Machinery Co.

INTERNATIONAL ROAD CONGRESS.—The second congress will be held at Brussels, Belgium, July 31-Aug. 6, 1910. The congress will be divided into two sections: A construction and maintenance section and a traffic and operation section. The traffic section will deal with such matters as road signals and the effect upon road surfaces of different kinds of rolling stock.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—A meeting will be held in the Engineering Societies' Building, New York City, Oct. 8, at which Mr. John B. Taylor, of Schenectady, N. Y., will present a paper on "Telegraph and Telephone Systems as Affected by Alternating-Current Lines." This paper is to be printed in the October "Proceedings" of the institute, which will be issued Oct. 1.

AMERICAN CIVIC ASSOCIATION.—The fifth annual convention will be held at Cincinnati, Ohio, Nov. 15-18 in conjunction with the 15th annual meeting of the National Municipal League. Papers will be presented on the conservation of natural resources, and among the subjects to be discussed are forestry, the smoke nuisance and the preservation of the scenic beauty of places such as Niagara Falls and the Yosemite Valley.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.—In connection with the annual convention at Philadelphia, Pa., Dec. 1-3, there will be an exhibition of trade school work from all sections of the United States. Bulletin No. 9 has been recently issued containing all the addresses delivered at the annual convention in Atlanta, Ga., last year. The secretary is Mr. James C. Monaghan, 20 W. 44th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The first meeting for the coming season will be held in the Engineering Societies' Building, New York City, Oct. 12. A paper on "The High-Pressure Fire-Service Pumps of Manhattan Borough, City of New York," will be presented by Professor R. C. Carpenter, of Cornell University. This paper, which was published in the September "Journal" of the society, describes the arrangement of the mains and the pumping stations and gives the results of 24-hour tests of the five-stage centrifugal pumps.

AMERICAN MINING CONGRESS.—At the twelfth annual meeting Sept. 27-Oct. 2, in Goldfield, Nev., all technical papers are to read by title only. Among the addresses to be delivered are the following: "A Federal Bureau of Mines," by D. W. Brunton, Denver, Colo., and W. F. Englebright, California; "Need of a National Mining Research Laboratory," by Thos. F. Walsh, Colorado; "The Future of the Copper Mining Industry," by Horace J. Stevens, Houghton, Mich.; "Purchase of Coal by B. T. U. Method," by Samuel A. Taylor, Pittsburg, Pa.; "Mine Accidents and a Coal Tax Insurance Fund," by S. A. Taylor, Pittsburg, Pa., Glen W. Traer, Chicago, Ill., John H. Jones, Pittsburg, Pa., and David Ross, Springfield, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.—The fall meeting of the structural section at Pittsburg, Pa., Sept. 7, was devoted to the discussion of contracts with special reference to structural steel work. Specially prepared discussions were given as follows: "Liabilities for Uncompleted Contracts," "Penalties and Bonuses" and "Damages for Failure to Complete," W. B. Adair, attorney; "Liability for Damages During Construction," H. M. Stilley, attorney; "Arbitrations," S. A. Schreiner, attorney; "Payments," L. J. Affelder, Contract Manager for the American Bridge Co. Several engineers and architects discussed the relations of parties interested in a contract, giving forms of contracts of unusual merit.

At the meeting of the society held Sept. 21, W. W. Macfarren presented a paper on "The Possibilities of the Commercial Automobile."